3.0

Conservation and Coastal Management Element

Table of Contents

List of Tables

3.0 Conservation and Coastal Management Element

3.1 Environmental Setting of the Florida Keys

The low-lying limestone islands comprising the Florida Keys extend 233 miles (375 km) southwestward in a gradual arc from Biscayne Bay at the southeastern tip of the Florida peninsula to the Dry Tortugas in the Gulf of Mexico. Southeast of the Keys is the Florida Reef Tract, a continuous band of coral reefs bordering the Straits of Florida, lying five to seven miles offshore and extending 220 miles (354 km) from Soldier Key to the Dry Tortugas. To the west and northwest is Florida Bay, a shallow embayment of the Gulf of Mexico with an extensive network of carbonate mud shoals and seagrass beds (Florida DER, 1987d). At the top of the Upper Keys, Card Sound and Barnes Sound are shallow embayments which tie into Biscayne Bay.

3.2 Climate

The Florida Keys experience a subtropical savanna-type climate characterized by warm humid summers and mild dry winters. The mean annual sunshine is 3,300 hours, ten percent more than the Florida Peninsula to the north.

The average annual temperature in the Florida Keys ranges from a summer high of 89 degrees in July to a winter low of 63 degrees in February. Temperatures below freezing have not been recorded in the Keys, primarily due to the meliorative effects of the warm marine waters in the area and the presence of the warm Gulf Stream along the coast.

The average annual total precipitation in the Keys is estimated at 36 inches. Most of the rainfall comes in the wet season during the months of May through October. Winter rainfall accounts for less than one-third of the annual precipitation. Thunderstorms are the primary source of water during the wet season. During hot summer days, moist oceanic air heats up over the land, becoming unstable and rising. As the moisture condenses, thunderstorms form. This process is favored by the orientation of the Keys, which lie at approximate right angles to the prevailing easterlies. During the dry winter season, most of the rainfall is due to cold fronts which pass over the area on the average of once a week. Day-long dry-season storms are rare.

There is a net decrease in precipitation and seasonal differences in precipitation southward from the Upper Keys to the Lower Keys. This is due to two factors. Winter cold fronts do not pass into the Lower Keys as often as they pass into the Upper Keys. Further, convective thunderstorms do not develop as readily over small islands as they do over the mainland.

Prevailing tradewinds from the east and southeast in the Keys are relatively mild, averaging 11 to 12 knots throughout the year. The strongest winds occur during the winter months from December through March, when cold fronts move over the area from the northern quadrants.

The Keys lie in an area which is susceptible to tropical cyclones and hurricanes. These low pressure systems vary in intensity and orientation. Tropical depressions or disturbances are cyclones with winds of less that 38 miles per hour (mph). By comparison, tropical storms exhibit distinct circulation patterns, with winds exceeding 38 mph. When the maximum winds exceed 74 mph, the storm becomes a hurricane.

3.3 Physiography, Geology and Mineral Resources

3.3.1 Physiographic Features

The Florida Keys belong to the Southern Zone of the Coastal Lowlands physiographic province, also referred to as the Gold Coast and Florida Bay. This area lies south and southeast of Lake Okeechobee, is primarily underlain by Pleistocene limestone, and is characterized by low relief, poor drainage and extensive areas of coastal mangrove swamps. Elevations on the Keys are low, generally less than five feet above sea level. Most of the land area is only 2 to 3 feet above high tide. The highest point lies on Windley Key, where the maximum elevation is 18 feet above sea level.

The islands generally slope very gradually up from the sea to flattened, gently rounded tops (Lane, 1986). Irregularities of the rock surfaces are a result of the heterogeneous topography of the coral reefs that created the islands, and also the result of erosion and solution of the limestone rocks (Lane, 1986). Solution features, such as pitted and pinnacled surfaces occur throughout the Keys, including many sinkholes, filled with peat or carbonate sediments, up to several feet in diameter and several feet deep (Lane, 1986).

Geologically and physiographically, the Florida Keys can be divided into three main areas: the Upper Keys (Coral Reef Keys); the Lower Keys (Oolitic Keys); and, approximately 50 miles to the west, the distal atolls, otherwise known as the Dry Tortugas.

A. Upper Keys

The Upper Keys are a linear chain of islands made up primarily of limestone coral rock. The main axis of the islands lies parallel to the main access of the chain. They extend from Soldier Key in Dade County to the north, to the New Found Harbor Keys. On their seaward side lies a well developed reef tract composed of an outer fringe reef that borders the inner edge of the narrow continental shelf. Between the Keys and this relatively continuous outer fringe reef, shallower banks and deeper channels dotted with patch reefs run parallel to the islands. These living reefs, unique in the United States, are best developed in the Upper Keys area. Because corals are exceedingly sensitive to turbidity, their development is favored by the long orientation of the Upper Keys and the lack of tidal channels providing water circulation from Florida Bay. This blocks the influx of carbonate muds from the Bay and prevents silting of the reef tract.

B. Lower Keys

The Lower Keys are primarily composed of oolites, small spherical grains of calcium carbonate, cemented together to form a limestone. The axis of the islands runs at right angles to the general trend of the chain rather than parallel to it, as in the Upper Keys. The islands are separated by numerous long narrow channels. They extend from East Bahia Honda Key and Big Pine Key (excepting the southern tip of the island which belongs geologically to the Upper Keys) to the Marquesas. The modern coral reefs associated with the Lower Keys lie mostly to the south of the islands and are less developed than the northern reefs. This is due to the ready transfer of carbonate muds from Florida Bay to the reef tract through the channels separating the islands. The constant presence of mud increases the turbidity in the water and inhibits reef growth somewhat.

C. Dry Tortugas

Seventy miles to the west of Key West, the Dry Tortugas represent the last outlier islands of shallow sediments of the Florida Platform. These include approximately 30 roughly circular sand keys. Moving west from Key West, major features are the Boca Grande island group, the islands forming the Marquesas, the Quicksands Banks through Rebecca Shoals, and the islands of the Dry Tortugas, which are separated from Rebecca Shoals by a trough of relatively deeper water (CSA, 1991).

3.3.2 Geology

A. Structure and Geologic Setting

The Florida Keys, Florida Bay and Everglades National Park are underlain by the Floridan Plateau. This plateau separates the Gulf of Mexico from the Atlantic Ocean, extending offshore beyond the present land mass beneath all of the submerged areas surrounding the state to the edge of the continental shelf at approximately the 300 ft (90m) depth contour (SFWMD, 1991). In the Gulf, the plateau slopes gently to the west and extends out to 150 mi (240 km) offshore; on the south and east, the plateau drops off sharply into the Bahamas Trench approximately 5 to 7 miles offshore.

Marine carbonate sediments nearly 20,000 feet (6,000 m) in depth underlie the Keys. These sediments range in age from Jurassic to Holocene and have accumulated over a period of 136 million years above a Triassic-Jurassic basement of volcanic rocks (Antoine & Harding, 1963). Beneath the Florida Peninsula the rock floor is a truncated surface of various igneous and sedimentary rocks of chiefly Precambrian and early Paleozoic age (SFWMD, 1991).

B. Stratigraphy

Although the Mesozoic sediments represent thicknesses well in excess of 10,000 feet, only the more recent Cenozoic sediments have a direct bearing on the history and formation of the Keys. Of these, the most important are the sediments deposited since Miocene time, including the Miami Oolite, the Key Largo Limestone, the Tamiami Limestone and the Hawthorne Group.

Reconstruction of the past is complicated by oscillations in sea level which have occurred since Middle Tertiary Miocene times. Some 20,000 years ago, sea level may have been as low as 450 feet below present level. Geologic evidence, such as the presence of peat under Crane Key 4 to 10 feet below present sea level, indicates a much lower sea level as recently as 4,000 years ago. Recent indications are that sea level has risen some 8 to 10 inches during the past century alone.

Miami Oolite

The Miami Oolite is the surficial deposit which extends from Big Pine Key through Key West. It is a medium to hard limestone, white to yellowish in color, oolitic in places, rich in bryozoans in part, and may also contain some quartz sand. It underlies most of the Florida Bay where it is covered by varying thicknesses of calcareous mud derived from the disintegration of calcareous algae. This limestone is primarily represented by the oolitic facies and the bryozoan facies.

The Miami Oolite is a porous limestone containing numerous vertical solution features most likely formed during the Pleistocene. Because these features are not commonly connected, water does not move laterally as readily as in the Key Largo Limestone and, on the Florida Peninsula, they provide a supply of freshwater.

Key Largo Limestone

The Key Largo Limestone outcrops at the surface from Soldier Key to the southernmost end of Big Pine Key, over a distance of 110 miles. Subsurface drilling indicates that it originally extended from Miami to the Dry Tortugas, over twice its currently exposed length. It varies in thickness from 70 to over 170 feet. It is a fossil coral reef whose main structure is a network of coral heads with intervening spaces filled with detrital reef material. Star coral, and less commonly brain corals, are the dominant species found in the exposed Key Largo Limestone, indicating that the reef was once a patch reef. Seaward drilling away from the exposed portion of the limestone reveals the presence of moosehorn coral, a species characteristic of present fringe reefs. The lowering of the sea which allowed cementation of the Miami Limestone killed the reef as it emerged. The subsequent rise of the sea, which reshaped the oolitic limestone of the Lower Keys, also destroyed most of the outer fringe reef. Only the inner patch reef is visible today and forms the backbone of the Upper Keys.

The Key Largo Limestone is a very porous coralline limestone. It is riddled with solution features and voids, allowing water ready passage, both vertically and horizontally. Although an excellent potential aquifer, it contains very little freshwater because its permeability allows ready outflow.

Tamiami Limestone

The Tamiami Limestone is the oldest formation outcropping in South Florida. It is a tan to light grey limestone, quite variable in appearance, ranging from dense, to sandy, clayey and shelly, with some sandy units and some reef rock units. The Tamiami Limestone reaches a maximum thickness of 150 feet in the Miami area. To the west the formation thins rapidly.

In the Miami area the upper portion of the Tamiami Formation is one of the most permeable and productive formations of the Biscayne Aquifer. The upper portion is separated from the lower portion by an unconformity, which may or may not correspond to a hydrologic separation as well. The upper productive zone is composed of permeable limestones, underlain by relatively impermeable marls and limestones of the Lower Tamiami and Hawthorne Formations, which in part, form the confining beds between the deeper Floridan Aquifer and the shallower Biscayne Aquifer.

Although the Floridan has sufficient water pressure to allow artesian flow in the Keys, the high concentration of dissolved materials renders the water unfit for public consumption. Pennekamp Spring on Key Largo is a six-inch artesian well 1,300 feet deep in the Florida Aquifer. It has a chloride concentration of 2,440 mg/l, nearly ten times the recommended U.S. Public Health Service levels (Rosenau, et al., 1977).

Hawthorne Group
The Hawthorne Group underlies both the Miami Oolite and Key Largo Limestone and acts as a confining layers which inhibits the downward movement of groundwater. It separates the surficial aquifer system from the Floridan Aquifer System. It is relatively impermeable and consists of silt, clayey sand and sand. It is phosphatic and greenish in color. The formation averages approximately 60 to 90 m in thickness throughout the Florida Keys area.

3.3.3 Mineral Resources

A. Known Sources of Commercially Valuable Minerals and Existing Mineral Resource Extraction Activities

Mineral commodities that are available for production in South Florida generally include sand, limestone, and oil (Lane, 1981).

Limestone
In the Florida Keys, the resource extraction industry has historically been limited to limestone mining. Over most of the Keys, limestone occurs at the surface or at relatively shallow depths, beneath thin sand or peat deposits. Abandoned limestone mining pits, or "borrow pits" can be found throughout the Keys, where because of the low relief, they are typically filled with water. Nine limestone mining operations in the Keys have active Monroe County permits (see Table 3.1). These are found throughout both the Upper and Lower Keys. None are located on the Mainland. Material is mined by blasting and shovel removal. Generally water is not pumped from mining pits. Excavated material is used in the construction trades for fill, landscaping, cement manufacture, road construction, and shoreline protection.

The Year 2010 Comprehensive Plan Map Atlas includes soils maps showing the locations of active limestone mining operations in Monroe County. These maps are available at a scale of 1"=2,000' and can be reviewed at the Monroe County Department of Planning.

Sand
Compared to the rest of Florida, there is very little quartz sand on the Keys (Lane, 1986). Some offshore sand extraction has been undertaken by the Florida Department of Transportation to obtain fill for local improvements to US 1. Bare sand substrate is known to occur adjacent to the Keys' shoreline only in the vicinity of tidal channels of the Lower Keys and in the nearshore region of Boca Chica Key, Big Munson Island, Bahia Honda Key, Ohio Key and Grassy Key (Marszalek, 1984).

Oil
A total of seven oil wells have been drilled in Florida state waters of the South Florida Basin near the Florida Keys from 1947 through 1983 (Lloyd, 1991). One of these wells (drilled in 1959), located north of the Marquessa Islands, had a significant oil show (Lloyd, 1991). No commercial production was ever undertaken. No further drilling or geophysical oil exploration activity has occurred in the vicinity of the Keys. Effective July, 1990, all oil drilling activity was prohibited in Florida state waters. There have been no sales of federal oil and gas leases in the Straits of Florida Planning Area (Lloyd, 1991). This area encompasses the Straits of Florida on the Atlantic side of the Keys and the Florida Bay extending offshore from the Keys to the "Three League Line".

Table 3.1

Existing Limestone Mining Operations with Active Monroe County Permits

Key	Owner	Original Habitat
Rockland	Pinewood Enterprises, Inc.	Submerged Land
Rockland	CTB, Inc.	Submerged Land
Shark	Keevan	Submerged Land
Cudjoe	CTB, Inc.	Mangrove/Salt Marsh
Big Pine	CTB, Inc.	Mangrove
No Name	Krause	Mangrove/Salt Marsh
No Name	Pinewood Materials, Inc.	Pinelands
Long	Leisure Life Sales, Inc.	Mangrove/Salt Marsh
Key Largo	Cooke	Hardwood Hammock

Source: Monroe County Building Department, 1990.

B. Known Pollution Problems and/or Issues Related to Mineral Resource Extraction Operations

Existing and potential environmental problems related to mineral resource extraction activities in the Florida Keys include:

(a) accelerated sedimentation and erosion from disturbed areas;

(b) facilitation of saltwater intrusion into groundwater lenses;

(c) fugitive dust from disturbed areas;

(d) noise associated with blasting and operation of heavy equipment, machinery and trucks; and

(e) drainage, erosion, safety hazards and adverse visual impacts of abandoned and inactive mine sites.

The existing mining activities in the Keys are not currently required to conduct operations in accordance with an approved erosion and sedimentation control plan. During limestone mining operations an extensive area within and adjacent to the extraction site is typically disturbed. Natural drainage patterns are altered and large areas of unstabilized soil are exposed to the erosive potential of precipitation. Without adequate soil erosion and sedimentation control measures, this typically can result in accelerated soil erosion from mining sites and increased sedimentation of local surface water channels.

Limestone mining activities can facilitate saltwater intrusion into freshwater aquifers and lens areas. Several existing limestone mining operations in Monroe County are located on keys which have underlying freshwater lenses, including Big Pine Key, No Name Key and Cudjoe Key. Current Monroe County regulations limit excavations to sixty (60) feet in depth, regardless of location. No studies of saltwater intrusion specifically due to mining activities have been completed. While there is evidence of saltwater intrusion into the freshwater lens on Big Pine Key, this has been attributed to paving of recharge areas, dredging of boat basins and canals, and the withdrawal of groundwater by pumping, and not specifically to mining activities (Stewart, Wightman and Beaudoin, 1989).

The existing mining activities in the Keys are not currently required to conduct operations in accordance with an approved fugitive dust control plan. As a result, the extensive exposed soil surfaces and excavation activities at mining sites constitute a source of air-borne particulates, particularly on windy days. Where mining sites are located in close proximity to developed areas, the residential population may be exposed to periodically high concentrations of particulates. Only one limestone mine (Shark Key) is located in the vicinity of a residential area, and while the facility is permitted, it is not currently active.

The Monroe County Code regulates blasting activities but does not restrict noise levels from crushing and hauling activities. Consequently, noise impacts are not regulated where mining activity occurs in close proximity to residential uses.

Environmental problems at abandoned mining sites or sites at which extraction activities are no longer in operation are related to: stormwater and groundwater management; erosion and sedimentation control; safety to persons, wildlife and adjoining property; and visual impacts. Reclamation requirements of the County and the Florida Department of Natural Resources address each of these problem areas, exclusive of mitigation of visual impacts from inactive sites. Operators of existing and new mines in Monroe County are currently required to comply with restoration standards of the Land Development Regulations (Section 9.5-433). New mining activities, including those at existing mines as of January 1, 1989, are also required to comply with DNR limestone reclamation performance standards (Section 378.401, F.S.).

No regulations currently exist which require the owner of an abandoned or inactive mine site to reclaim or restore the property. There are numerous such mine sites in the Keys, several of which may constitute attractive nuisances.

C. Potential for Conservation, Use or Protection of Mineral Resources

Limestone

Additional regulations are needed to more fully address the environmental and public safety issues related to existing and new limestone mining activities and to abandoned mine sites.

It is unknown at this time whether existing or future limestone mining in certain areas of the County is causing accelerated saltwater intrusion into groundwater lenses. This is because the areal extent and depth of the freshwater lenses are not well documented. Additional research is needed to describe the fresh groundwater resources in the Keys, particularly on Big Pine Key. Once this research is completed, then appropriate regulations should be adopted which will protect the groundwater resources. These could include mining prohibitions in groundwater recharge areas and/or limits on the permitted excavation depth.

All mining activities should be conducted in accordance with an annual operating permit which requires annual updating of an erosion and sedimentation control plan, a fugitive dust control plan, documentation of current mining depth, and a reclamation plan. Annual inspection procedures should be implemented at each permitted facility to verify compliance with approved plans.

The County should undertake coordination with the Department of Natural Resources to review existing state and local mine permitting and reclamation standards for consistency and to determine the appropriate revisions to the Monroe County Code which will better protect the environment and residents of the County from the impacts of limestone mining.

With respect to abandoned mining sites, Monroe County should prepare and inventory of abandoned mining sites and, working where possible with landowners, develop plans for the cleanup and productive reuse of abandoned mining sites.

Sand and Oil

The National Marine Sanctuary Act (H.R.5909) prohibits leasing, exploration, development, or production of minerals or hydrocarbons within the Florida Keys National Marine Sanctuary.

3.4 Soils

3.4.1 Soils Inventory

The Soil Conservation Service of the U.S. Department of Agriculture has mapped sixteen soil units in the Florida Keys (exclusive of the mainland) (U.S.D.A., 1989). These include: (1) eleven soil series found only in the Keys; (2) beach soils; and (3) four soil complexes comprised of natural soils in combination with other substrate, such as rock outcrops, fill and/or crushed limestone.

Soil characteristics are correlated with topographic, hydrologic and vegetation conditions. Based upon these factors, the sixteen soil units in the Keys can be divided into six general groups, as follows:

Beach Soils:
Beaches (B)

Marine Wetland Soils: (Mangroves, Saltmarsh and Buttonwood Wetlands)
Cudjoe Marl (CM)
Keywest Marl (KW)
Lignumvitae Marl (LM)
Islamorada Muck (IM)
Key Largo Muck (KM)
Rock Outcrop-Cudjoe Complex (tidal) (RCT)
Rock Outcrop-Tavernier Complex (RT)

Tropical Hardwood Hammock Soils:
Bahia Honda Fine Sand (FS)
Matecumbe Muck (MM)
Pennekamp Gravelly Muck (extremely stony) (PM)
Saddlebunch Marl (SM)

Slash Pineland Soils:
Keyvaca Very Gravelly Loam (KL)

Freshwater Wetland Soils:
Rock Outcrop-Cudjoe Complex (frequently flooded) (RCF)

Filled and Developed Land:
Udorthents-Urban Land Complex (U)
Urban Land (UL).

Table 3.2 summarizes selected physical and chemical properties of the soil units. Table 3.3 summarizes the soil and water features for each soil unit.

The Year 2010 Comprehensive Plan Map Atlas includes soils maps showing areas within Monroe County characterized by each of the sixteen soil units found in the Keys. These maps are available at a scale of 1"=2,000' and can be reviewed at the Monroe County Department of Planning.

Table 3.2

Monroe County Soils - Physical and Chemical Properties of Soils

Map Symbol	Soil Name	Depth (In.)	Texture (U.S.D.A.)	Permeability (In./Hr.)	Soil Reaction (pH)	Organic Matter (Pct.)	Erodibility Factors K	T
Beach Soils								
B	Beaches	0-6	Sand	> 6.0	-	< 0.1	0.05	5
		6-60	Coarse sand, sand, fine sand	> 6.0	-	< 0.1	0.05	5
Marine Wetland Soils								
CM	Cudjoe	0-16	Marl	0.6-6.0	6.6-8.4	1-5	0.32	1
		16	Weathered bedrock	-	-		-	
KW	Keywest	0-9	Marl	0.6-6.0	6.6-8.4	1-5	0.32	4
		9-15	Muck	6.0-20	6.1-7.8		0.05	
		15-27	Mucky Marl	2.0-6.0	6.6-8.4		0.28	
		27-65	Marl	0.6-6.0	6.6-8.4		0.32	
		65	Weathered bedrock	-	-		-	
LM	Lignumvitae	0-32	Marl	0.6-6.0	6.6-8.4	1-5	0.32	2
		32	Weathered bedrock	-	-		-	
IM	Islamorada	0-35	Muck	6.0-20.0	6.1-7.8	75-90	-	-
		35	Weathered bedrock	-	-		-	
KM	Keylargo	0-70	Muck	6.0-20.0	6.1-7.8	75-90	-	-
		70	Weathered bedrock	-	-		-	
RCT	Rock Outcrop	0-60	Unweathered bedrock	-	-	-	-	-
RT	Rock Outcrop	0-60	Unweathered bedrock	-	-	-	-	-
Tropical Hammock Association Soils								
FS	Bahiahonda	0-8	Fine sand	6.0-20.0	6.6-7.8	1-3	0.05	5
		8-68	Sand, fine sand	6.0-20.0	6.6-7.8		0.05	
		68-82	Gravelly sand, very gravelly sand	> 20	7.4-8.4		0.02	
		82	Weathered bedrock	-	-		-	
MM	Matecumbe	0-3	Muck	6.0-20.0	5.6-7.3	80-90	-	-
		3-5	Muck, gravelly muck	6.0-20.0	5.6-7.3		-	
		5	Weathered bedrock	-			-	
PM	Pennekamp	0-3	Gravelly muck	2.0-6.0	5.6-6.5	40-70	-	-
		3-8	Very gravelly loam, very gravelly silt loam, extremely gravelly loam,	2.0-6.0	7.4-8.4		0.1	
		8	weathered bedrock	-	-		-	
SM	Saddlebunch	0-17	Marl	0.6-6.0	6.6-8.4	1-5	0.32	1
		17	Weathered bedrock	-	-		-	
Slash Pineland Soils								
KL	Keyvaca	0-4	Very gravelly loam	2.0-6.0	7.4-8.4	2-6	0.05	1
		4	Weathered bedrock	-	-		-	
Freshwater Wetland Soils								
RCF	Rock Outcrop	0-60	Unweathered bedrock	-	-	-	-	-
Filled and Developed Land								
U	Udorthents	0-32	Extremely gravelly sand	6.0-20.0	7.4-8.4	1-2	0.02	5
		32-62	Marl	0.6-6.0	6.6-8.4		0.32	
UL	Urban Land	0-6	Variable	-	-	-	-	-

Notes:
1. Absense of an entry indicates that data were not available or were not estimated.
2. Entries under Organic Matter apply only to the surface layer.
3. For RCT, RT, and U soils, see description of the map unit for composition and behavior characteristics of the map unit.

Source: U.S.D.A., 1989.

Table 3.3

Monroe County Soils - Soil and Water Features

Map Symbol	Soil Name	Hydrologic Soil Group	Flooding Frequency	Flooding Duration	Flooding Months	High Water Table Depth (ft.)	High Water Table Kind	High Water Table Months	Bedrock Depth (ft.)	Bedrock Hardness
Beach Soils										
B	Beaches	D	Frequent	Very brief to long	Jan-Dec	0-6.0	Apparent	Jan-Dec	> 60	-
Marine Wetland Soils										
CM	Cudjoe	D	Frequent	Brief to long	Jan-Dec	0-0.5	Apparent	Jan-Dec	20-40	Soft
KW	Keywest	D	Frequent	Long	Jan-Dec	0-0.5	Apparent	Jan-Dec	40-90	Soft
LM	Lignumvitae	D	Frequent	Long	Jan-Dec	0-0.5	Apparent	Jan-Dec	20-40	Soft
IM	Islamorada	D	Frequent	Very long	Jan-Dec	0	Apparent	Jan-Dec	20-50	Soft
KM	Keylargo	D	Frequent	Very long	Jan-Dec	0	Apparent	Jan-Dec	51-90	Soft
RCT	Rock Outcrop	D	Frequent	-	-	> 6.0	-	-	0	Hard
RT	Rock Outcrop	D	Frequent		-	> 6.0	-	-	0	Hard
Tropical Hammock Association Soils										
FS	Bahiahonda	B	Rare	-	-	2.5-3.5	Apparent	Jun-Nov	60-90	Soft
MM	Matecumbe	D	Occasional	Brief	Jul-Dec	1.5-3.0	Apparent	Jul-Dec	2-9	Soft
PM	Pennekamp	D	Rare	-	-	3.5-5.0	Apparent	Jun-Nov	4-16	Soft
SM	Saddlebunch	D	Occasional	Long	Jun-Nov	0.5-1.0	Apparent	Jun-Nov	4-20	Soft
Slash Pineland Soils										
KL	Keyvaca	D	Rare	-	-	3.0-5.0	Apparent	Jun-Nov	3-6	Soft
Freshwater Wetland Soils										
RCF	Rock Outcrop	D	Frequent	-	-	> 6.0	-	-	0	Hard
Filled and Developed Land										
U	Udorthents	B	Rare	-	-	2.0-4.0	Apparent	Jan-Dec	60-90	Soft
UL	Urban Land	-	Rare	-	-	> 2.0	-	-	> 10	-

Notes:
1. Absense of an entry indicates that data were no available or were not estimated.
2. For RCT, RT, RCF, and U soils, see description of the map unit for composition and behavior characteristics of the map unit.

Source: U.S.D.A., 1989.

A. Beach Soils

Approximately 100 acres of beach (B) soils occur in the Keys. These include beaches adjacent to the Atlantic Ocean on Long Key and the Lower Keys. Slopes are generally 1 to 2 percent.

B. Marine Wetland Soils (Mangroves, Saltmarsh and Buttonwood Wetlands)

Cudjoe Marl (CM), Keywest Marl (KW) and Lignumvitae Marl (LM) occur on tidal, sparsely vegetated mangrove swamps. Cudjoe and Keywest soils occur primarily in the Lower Keys. Cudjoe soils are loamy, carbonatic, isohyperthermic, shallow Tropic Fluvaquents (3,410 acres). Keywest soils are coarse silty, carbonatic, isohyperthermic Thapto-Histic Tropic Fluvaquents (450 acres). Lignumvitae soils, more common in the Middle Keys, are coarse, silty, carbonatic isohyperthermic Tropic Fluvaquents (1,360 acres). All three soils are frequently flooded for long duration by tidal action and tropical storms.

Islamorada Muck (IM), Keylargo Muck (KM), Rock Outcrop-Cudjoe Complex (tidal) (RCT) and Rock Outcrop-Tavernier Complex (RT) occur on tidal, densely vegetated mangrove swamps. Islamorada and Keylargo soils occur primarily in the Upper Keys. Islamorada soils are euic, isohyperthermic Lithic Troposaprists (5,890 acres). Keylargo soils are euic, isohyperthermic Typic Troposaprists (12,240 acres). Both soils are frequently flooded by daily tidal action. The Rock Outcrop-Cudjoe Complex is found throughout the Keys, and consists of 60 percent rock outcrop and 40 percent Cudjoe Marl (5,750 acres). The Rock Outcrop-Tavernier Complex occurs primarily in the Upper Keys, and consists of 65 percent rock outcrop and 35 percent Tavernier Muck (920 acres). Both soil complexes are frequently flooded by tidal action and tropical storms.

C. Tropical Hardwood Hammock Soils

Bahiahonda Fine Sand (FS) occurs on approximately 240 acres of coastal dunes and tropical hammocks on Long Key and Bahia Honda Key. The soils are isohyperthermic, uncoated Aquic Quartzipasamments. They are rarely flooded and have a high water table of 2.5 to 3.5 feet.

Matecumbe Muck (MM) occurs on tropical hammocks throughout the Keys (4,680 acres). The soils are euic, isohyperthermic Lithic Tropofolists. They have a high water table of 1.5 to 3 feet and are occasionally flooded by hurricanes and other tropical storms.

Pennekamp Gravelly Muck (extremely stony) (PM) occurs on tropical hammock uplands of the Upper Keys (6,980 acres). Pennekamp soils are loamy-skeletal, carbonatic, isohyperthermic Lithic Rendolls. Approximately 20 percent of the surface is typically covered by stones. The soils are rarely flooded by hurricanes and other tropical storms and have a high water table of 3.5 to 5 feet.

Saddlebunch Marl (SM) occurs on tropical hammock uplands of the Lower Keys (1,140 acres). Saddlebunch soils are loamy, carbonatic, isohyperthermic shallow Tropic Fluvaquents. They are occasionally flooded for brief periods by surface runoff from adjacent higher land.

D. Pineland Soils

Keyvaca very gravelly loam (KL) occurs in the pinelands of Big Pine Key and adjacent keys (2,720 acres). The soils are loamy, skeletal, carbonatic, isohyperthermic Lithic Rendolls. Approximately 10 percent of the surface is typically covered by stones. The soils are rarely flooded by hurricanes and other tropical storms and have a high water table of 3 to 5 feet.

E. Freshwater Wetland Soils

The Rock-Outcrop Cudjoe Complex (RCF) occurs on the sawgrass dominated freshwater wetlands of Big Pine Key and adjacent keys (1,840 acres). It consists of 55 percent rock outcrop and 45 percent Cudjoe Marl. The soils are frequently flooded by surface runoff from adjacent higher land.

F. Filled and Developed Land

Filled and developed lands characterized by the Udorthents-Urban Land Complex (U) and Urban Land soils occupy approximately 14,000 acres of the Keys, or 21 percent of the land area.

The Udorthents-Urban Land Complex (U) occurs on coastal uplands. These areas were created to allow for new development by placement of crushed limestone over marl and other soil materials (10,940 acres). Up to 40 percent of the mapped areas are covered by urban structures.

Urban Land (U) occurs on uplands that are 80 percent covered by urban development on Key West and adjacent keys (3,080 acres).

3.4.2 Soil Limitations for Developed Uses

Soils in the Florida Keys are severely constrained for developed uses, including shallow excavations, dwellings without basements, local roads and streets, and septic tank absorption fields (see Table 3.4). The U.S.D.A. defines severely constrained as follows:

> "presence of limitations which normally cannot be overcome without exceptional, complex, or costly measures. Some limitations can be improved by reducing or removing the limiting soil feature, but in most situations it is difficult and costly (U.S.D.A., 1978)."

In the Keys, the soils are most commonly severely constrained due to shallow depth to bedrock, flooding, and wetness. Localized limiting characteristics include excessive humus, tendency to cave, low strength, poor filtration capability, subsidence potential, excessive salt, and presence of large stones.Soils characterized as "urban land" are potentially better development sites when compared to natural soils in the Keys. These soils have "variable" limitations for developed uses, reflecting their history of disturbance. Most of these areas are already fully developed.

Table 3.4

Monroe County Soils - Soil Limitation Ratings for Selected Developed Uses

Map Symbol	Soil Name	Acres	Percent of Total Acres	Soil Limitations for Developed Uses: Shallow Excavations	Dwellings w/o Basements	Local Roads and Streets	Septic Tank Absorption Fields
Beach Soils							
B	Beaches	100	0.2	Severe (CC,W)	Severe (F,W)	Severe (F)	Severe (F,W,PF)
Marine Wetland Soils							
CM	Cudjoe	3,410	5.2	Severe (D,W)	Severe (F,W,LS)	Severe (W,F)	Severe (F,D,W)
KW	Keywest	450	0.7	Severe (H,W)	Severe (F,W,LS)	Severe (W,F)	Severe (F,W)
LM	Lignumvitae	1,360	2.1	Severe (H,W)	Severe (F,W,LS)	Severe (W,F)	Severe (F,D,W)
IM	Islamorada	5,890	8.9	Severe (H,W)	Severe (S,F,W)	Severe (S,W,F)	Severe (F,D,W)
KM	Keylargo	12,240	18.5	Severe (H,W)	Severe (S,F,W)	Severe (S,W,F)	Severe (F,D,W)
RCT	Rock Outcrop	5,750	8.7	Severe (D)	Severe (D)	Severe (D)	Severe (F,D)
RT	Rock Outcrop	920	1.4	Severe (D)	Severe (F,D)	Severe (D)	Severe (F,D)
Tropical Hammock Association Soils							
FS	Bahiahonda	240	0.4	Severe (CC)	Severe (F)	Moderate (F)	Severe (W,PF)
MM	Matecumbe	5,430	8.2	Severe (F,W)	Severe (F)	Severe (F)	Severe (F,D,W)
PM	Pennekamp	6,980	10.6	Severe (F)	Severe (F)	Moderate (D,F)	Severe (D,W)
SM	Saddlebunch	1,140	1.7	Severe (X,S,D,W)	Severe (F,W,LS)	Severe (F)	Severe (F,D,W)
Slash Pineland Soils							
KL	Keyvaca	2,780	4.2	Severe (D)	Severe (F)	Moderate (D,F)	Severe (D,W)
Freshwater Wetland Soils							
RCF	Rock Outcrop	1,840	2.8	Severe (D)	Severe (F,D)	Severe (D)	Severe (F,D)
Filled and Developed Land							
U	Udorthents	10,940	16.6	Severe (CC,W)	Severe (F)	Moderate (W,F,ST)	Severe (W,PF)
UL	Urban Land	3,080	4.7	Variable	Variable	Variable	Variable

Limiting Conditions:
- CC - cutbanks cave
- D - depth to rock
- F - flooding
- H - excessive humus
- LS - low strength
- PF - poor filter
- S - subsides
- ST - large stones
- W - wetness
- X - excess salt

Limitation Definitions:

Slight: Little or no limitation or limitations easily corrected by the use of normal equipment. Good performance and low maintenance can be expected.

Moderate: Presence of some limitation which normally can be overcome by careful design and management at somewhat greater costs. During some part of the year the performance of the structure or other planned use is somewhat less desirable than for soils rated slight.

Severe: Presence of limitations which normally cannot be overcome without exceptional, complex, or costly measures. Some limitations can be improved by reducing or removing the limiting soil feature, but in most situations it is difficult and costly.

Note: The information in this table does not eliminate the need for on-site investigation.

Source: U.S.D.A., 1989.

3.4.3 Areas Known by the Local Soil and Water Conservation District to Have Experienced Soil Erosion Problems

A. Identification of Soil Erosion Problem Areas

To date, no soil erosion problems have been identified by the USDA Soil Conservation Service or by the South Dade Soil and Water Conservation District in Monroe County (USDA, SCS, District Conservationist, September 15, 1991).

The Monroe County Department of Environmental Resources has identified several types of sites where accelerated erosion and sedimentation has or may occur in the Florida Keys:

(a) construction sites;
(b) existing developments where there is inadequate stormwater management;
(c) active limestone mining sites;
(d) unstable dredged spoil disposal sites;
(e) beaches; and
(f) altered shorelines.

B. Existing Commercial, Recreational or Conservation Uses in Soil Erosion Problem Areas

Information specifically locating existing and potential sites of accelerated erosion and sedimentation in the Keys is not available, except for active limestone mining sites.

The potential problem of construction site erosion occurs anywhere there is development activity. In the Keys, as in most communities, development activity includes a mix of residential, commercial and industrial activities, as well as limited development of active recreation facilities.

Existing developments where there are problems of accelerated erosion and sedimentation due to inadequate stormwater drainage also occur throughout the Keys and include a mix of residential, commercial and industrial activities.

Active limestone mining occurs at eight sites in the Keys (see Table 3.1). These are commercial uses, all but two or which are located in the Lower Keys.

Unstable dredged material disposal sites occur in isolated locations along residential canals in developed and partially developed subdivisions.

Beach erosion is typically due to natural causes, exacerbated by human activities (walking, off-road vehicles, and disturbances associated with adjacent development) which have disturbed natural beach vegetation, facilitated colonization by invasive plants, and weakened the sandy beach substrate. DNR has identified seven beaches in the Keys which are experiencing natural beach erosion (Florida DNR, 1989b):

Long Key State Recreation Area Beach
Coco Plum Beach

Sombrero Beach
Bahia Honda State Recreation Area Beach
Long Beach
Sugarloaf Beach
Boca Chica Beach.

Coco Plum Beach, Long Beach, and Sugarloaf Beach are in private ownership. The remaining beaches are publicly-owned and open to the public for recreation. Beach erosion due to human activities has been greatest, although not a significant problem, on Coco Plum Beach and Grassy Key Beach.

Accelerated shoreline erosion (exclusive of beaches) occurs in the Florida Keys where natural shorelines are disturbed or altered and then left unstabilized and exposed to the erosive forces of estuarine waters, precipitation and stormwater runoff. Although not widespread, such areas can be found in limited locations on most keys in residential areas along artificial canals where fringing mangroves have been disturbed. Shoreline erosion is not common on open water shorelines, except for the beaches noted above.

C. Known Pollution Problems and/or Issues Related to Soil Erosion Problem Areas

Exposure of unstabilized soil during construction is a source of stormwater pollutant loading. Runoff collects unstabilized soil material and pollutants from the ground surface, transporting them to surface drainage channels and ultimately to groundwater or nearshore waters.

Erosion due to poor stormwater management is typically a problem of older subdivisions in the Keys where drainage is inadequate to handle runoff discharges from major short-duration, high intensity storms. During such events, the concentration of runoff in unstablized and undersized drainageways results in localized accelerated erosion and consequent sedimentation of ditches and residential canals.

The existing mining activities in the Keys are not currently required to conduct operations in accordance with an approved erosion and sedimentation control plan. During limestone mining operations an extensive area within and adjacent to the extraction site is typically disturbed. Natural drainage patterns are altered and large areas of unstabilized soil are exposed to the erosive potential of precipitation. Without adequate soil erosion and sedimentation control measures, this typically can result in accelerated soil erosion from mining sites and increased sedimentation of local surface water channels.

Dredged spoil is comprised of bottom sediments removed from the dredging site. Typically these sediments are fine-textured silts and muds, very susceptible to erosion. When deposited on upland sites and not properly stabilized, they can be carried in stormwater and discharged into surface drainage channels or nearshore waters. Unstabilized dredge spoil containing contaminants such as heavy metals are a particular source of pollutants loadings.

Unstabilized shoreline areas are directly exposed to the erosive potential of tides, boat wakes, and storm waves. Consequently they are a source of sedimentation and nearshore water pollution.

D. Potential for Conservation, Use or Protection of Soil Erosion Problem Areas

In Monroe County, conditions attached to land development orders identify required erosion and sedimentation control measures for construction sites. A more comprehensive approach to erosion and sedimentation control would be through implementation of a stormwater management ordinance, applicable to all land development activity, which establishes criteria for both stormwater quantity and stormwater quality. Accompanying this ordinance should be a set of best management practices for soil erosion and sedimentation control developed explicitly for use in the Florida Keys.

Erosion problem areas in existing subdivisions and from dredged spoil disposal sites in the Keys could be eliminated through drainage improvements designed to reduce stormwater runoff volumes and rates of discharge. A county-wide stormwater management master plan is needed to address these problems. This would include an inventory of natural and man-made stormwater conveyance, treatment and discharge systems, with identification of drainage and erosion problem areas. Stormwater management facilities needed to mitigate drainage and erosion problems should be identified and funding sought to make necessary drainage improvements.

All mining activities should be conducted in accordance with an annual operating permit which requires annual updating of an erosion and sedimentation control plan and a reclamation plan. Annual inspection procedures should be implemented at each permitted facility to verify compliance with approved plans.

The County should undertake coordination with the Department of Natural Resources to review existing state and local mine permitting and reclamation standards for consistency and to determine the appropriate revisions to the Monroe County Code which will better protect the environment and residents of the County from the impacts of limestone mining.

Beach erosion can be mitigated through a combination of beach renourishment and restoration of natural beach vegetation. At present there are no ongoing beach renourishment projects in the Keys. Beach management plans are needed for public beaches to address problems of erosion and invasive plants. Beach renourishment is under consideration as a restoration option for Long Key State Recreation Area Beach, Sombrero Beach, and Bahia Honda Beach.

Shoreline erosion problem areas could be controlled using vegetative or structural stabilization techniques. Along open water shorelines, and along altered shorelines where shoreline erosion is less severe and there is a residual mangrove fringe remaining, it is preferable and possible to restore the natural shoreline. This will retain and/or restore the biological functions of the shoreline community providing shoreline stabilization, local storm buffering and water quality benefits. Along altered shorelines where erosion is advanced and the mangrove fringe is destroyed, then riprap, sloping rock revetments, or vertical shoreline structures may be necessary to curb further shoreline erosion. Improvements to shoreline erosion areas should be required at the time of permit issuance for improvements of any kind on a property on which such erosion problems are occurring.

3.5 Marine Water Resources

3.5.1 Hydrographic Setting

A. Overview

The Florida Keys lie between the lagoonal system of the Florida Bay and the oceanic waters of the Atlantic Ocean. North Key Largo is the only exception, located between the Atlantic Ocean and Card Sound and Barnes Sound, within the watershed of Biscayne Bay. Waters of Florida Bay, Biscayne Bay the Atlantic Ocean offshore of the Keys are tropical and oligotrophic, characterized by a mosaic of interacting biological communities, including coral reefs, seagrass beds, and mangrove forests.

The configuration and orientation of the Keys control the nature of tidal mixing between the estuarine waters and the oceanic waters. The islands comprising the Upper Keys constitute a continuous barrier to the exchange of water between Florida Bay, Biscayne Bay and the Atlantic Ocean. In Monroe County, only a few small tidal creeks on Key Largo allow minor interaction between the bays and the ocean. The largest of these are Tavernier Creek and the Broad Creek/Angelfish Creek inlet complex (from Card Sound in the Biscayne Bay estuary system to the Atlantic Ocean) in the northernmost portion of North Key Largo.

In the Lower Keys, the islands are separated by numerous long narrow channels. These channels, or tidal passes, allow for astronomical and wind-driven circulation between the estuary and ocean waters (Lapointe, 1990).

Some cyclical lateral flow of groundwater occurs throughout the Keys from one side of the islands to the other (Ginsburg, 1956; Chester, 1974; and Enos, 1977). This is the result of the porosity of the Miami limestone and the Key Largo limestone, tidal gradients, and the narrow width of the Keys.

B. Florida Bay

Florida Bay is an extensive shallow estuarine receiving basin for runoff from the mainland Florida. The Bay varies from a positive functioning estuary during high rainfall years to a tropical, highly saline, lagoon during years when evaporation exceeds upland runoff and oceanic exchange (Tilmant, 1989). Circulation within the Bay is primarily tide and wind driven. Florida Bay is generally isolated from the Gulf Loop Current and Florida Current.

The most significant environmental parameters affecting Florida Bay are the quantity, quality, distribution, and timing of freshwater runoff from the Florida mainland. Contributing drainage routes to the Bay include Shark Slough and associated estuaries on the western side; and Taylor Slough and the C-111 basin on the east. There is an inverse relationship between salinity in northern Florida Bay and the height of the south Florida groundwater table (Tabb, 1967; Thomas, 1974; SFWMD, 1991).

The most characteristic feature of Florida Bay is an anastomosing array of shallow mud banks composed of shelly calcareous silts that cordon the bay into a lacework of inteconnected shallow basins, referred to as "lakes" (Multer, 1977). These basins are generally shallow, five to six feet deep, and nowhere do they exceed depths of ten feet (Ginsburg, 1964).

Florida Bay, north of Long Key, is comprised of three hydrographic zones (Turney and Perkins, 1972; Enos and Perkins, 1979; Merriam, 1989), encompassing numerous sounds, bays, basins, channels, creeks and harbors. These zones do not include Manatee Bay and Barnes Sound at the northeastern end of the Upper Keys. These two sounds are part of the Card and Barnes Sound watershed, which is bordered on the west by U.S.1 and an eastern projection of the Atlantic coastal Ridge (which separates it from Biscayne bay to the north)(Hoffmeister, 1974).

The Eastern Bay is characterized by broad rounded depressions and considerable freshwater influence (SFWMD, 1991). Within the Eastern Bay's Upper Basin there are several completely enclosed hydrographic basins, or sounds. The more northerly sounds (Long Sound and Little Blackwater Sound) lie in the "runoff zone" and are the most influenced by freshwater flow from the mainland (SFWMD, 1991). The southern sounds (Blackwater Sound, Tarpon Basin and Buttonwood Sound) lie in the "interior zone" or Florida Bay, and show the greatest fluctuations in salinities (Ginsburg and Lowenstam, 1958; Schmidt and Davis, 1978; SFWMD, 1991). The Central Bay is characterized by small basins, shallow water, and restricted tidal flow (SFWMD, 1991). The Western Bay experiences more tidal exchange than the upper two bays (SFWMD, 1991) due to the presence of tidal channels between the Keys south of Upper Matecumbe Key.

Much of Florida Bay is characterized by extensive seagrass beds. The majority of the carbonate sediments on the Gulf side of the Lower Keys have been trapped by the marine grass Thalassia testudinum and calcareous green alga Halimeda opuntia (Schomer and Drew, 1982).

C. Atlantic Ocean

The shallow submerged seastrate on the east side of the Florida Keys extends from the shoreline to the shallow shelf break at the edge of the Floridan Plateau. There at the -300-feet depth, approximately 3 to 7 miles offshore, the bottom falls off into the Bahamas Trench.

The Florida Current, running south and east of the Keys generally controls the hydrology of the oceanic waters landward of the Straits of Florida. Circulation is influenced by tides and winds, both of which vary by season. In winter, water movement is toward the south-southwest, caused in part by changes in atmospheric pressure. In summer, waters move in a northeastern pattern in response to southeast winds.

Shoreline features of the Atlantic coastline include small tidal creeks, harbors, and embayments. Major tidal channels connecting to the northern basins of Florida Bay include Tea Table Channel, Indian Key Channel, Lignumvitae Channel, Channel Two and Channel Five. Numerous large channels provide connections between the oceanic waters and the shallow nearshore waters in the Lower Keys.

Shallow water less than 20 feet in depth extends approximately two miles offshore in the Upper Keys. In the Lower Keys, depths drop to twenty feet within one to two miles of the shoreline.

The nearshore area is typified by a belt of exposed rocky bottom. The intertidal zone is a broad, shallow shelf of exposed bedrock material with a thin veneer of sediment. The bedrock surface is crenelate and solution pocked, the result of the soluble nature of limestone and the burrowing and boring organisms that inhabit the intertidal zone (Florida DNR, 1991c).

In subtidal areas the hardbottom is interspersed with accumulations of calcareous mud associated with areas of restricted circulation. This mud is extremely fine and is the product of the decomposition of calcareous algal skeletons (Enos, 1977). Some mud is produced within Florida Bay and is introduced through tidal channels. Where mud depth exceeds 3 inches and where current velocities are low, the mud bottom is stabilized by seagrasses (Scoffin, 1970). In contrast, where sediment is thin, the bottom is colonized by hardbottom coral communities. Patch reefs develop on the sand, mud and rock substrate of the Straits of Florida where light, nutrient, and current conditions are favorable and where the bottom is protected from nutrients and sediment circulating from Florida Bay. Bank reefs of the Florida Reef Tract occur at or near the shallow shelf break at the edge of the Straits of Florida, where they are bathed by warm waters of the Florida Current.

Bare sand substrate is known to occur adjacent to the Keys' shoreline in the vicinity of tidal channels of the Lower Keys and in the nearshore region of Boca Chica Key, Big Munson Island, Bahia Honda Key, Ohio Key and Grassy Key (Marszalek, 1984).

3.5.2 Ambient Water Quality Conditions

There is a common public perception in the Florida Keys that water quality is deteriorated in recent years and that the documented decline in coral reef and seagrass biological communities is the result of water contamination from anthropogenic sources. Researchers looking at nearshore and confined waters have documented deteriorated water quality conditions and identified various human activities which appear to be causing these impacts. There is agreement that a range of human activities are discharging contaminants into the nearshore waters of the Keys. There is not agreement as to the specific loadings associated with these activities and their effects on offshore seagrass and coral communities.

The waters of the Florida Keys are largely included within the limits of the Florida Keys National Marine Sanctuary (FKNMS). The purpose of this sanctuary designation, and the water quality and general management programs required as a result of this designation are discussed in more detail below in Section 3.5.3. Presently, EPA, DER, NOAA, SFWMD, and Monroe County are working cooperatively on a Water Quality Protection Program for this latest of National Marine Sanctuaries. An initial goal of this effort is to reach consensus among researchers and regulators as to the condition of Florida Keys nearshore and offshore waters, and to agree as to the extent to which existing data can confirm relationships among human activities, water quality, and the evident decline in seagrass and coral reef communities within the Sanctuary.

A. Overview of Studies Evaluating Present Status and Trends in Water Quality

Comprehensive long-term water quality monitoring data are not available for Florida Keys waters. In a recent DER report, the state ranked Monroe County's waters as the least studied in the state, with over 90 percent of its waters still unassessed for water quality (Florida DER, 1988c).

Phase I of the Florida Keys National Marine Sanctuary (FKNMS) Water Quality Protection Program (CSA, 1991) confirms this finding, stating that:

> "The studies summarized not only provide an overview of the water quality in the [FKNMS], but they also indicate the relative paucity of data presently available to assess the water quality of the Keys. Insufficient data were available to demonstrate temporal changes in water quality because well designed, long-term studies have not been conducted."

Past water quality studies have been limited by-and-large to short-term (one year or less) water quality monitoring, usually comparing impacted or developed sites to undeveloped or offshore control sites. Impacted sites typically have included artificial water bodies such as canals.

Since 1985 there have been three water quality studies of a larger scale undertaken in the Florida Keys:

Florida Department of Environmental Regulation. 1985. Proposed designation of the waters of the Florida Keys as Outstanding Florida Waters. DER, Tallahassee, Florida. 56 pp. plus appendices.

Florida Department of Environmental Regulation. 1987d. Florida Keys monitoring study, water quality assessment of five selected pollutant sources in Marathon, Florida Keys. DER, Marathon, Florida. 196 pp.

Lapointe, B.E. and M.W. Clark. 1990a. Final report: Spatial and temporal variability in tropic state of surface waters in Monroe County during 1989-1990. Florida Keys Land and Sea Trust, Marathon, Florida. 81 pp.

CSA (1991) identified several additional studies which provide data on water quality in the Florida Keys including: Applied Biology, Inc., 1985; Bader et al., 1971; DER 1990b; Nnaji, 1987; Schmidt et al., 1978; Skinner et al., 1986; Skinner et al., 1989; and Szmandt, 1991.

DER, 1985

In 1985, DER undertook a comprehensive review of water quality conditions in the Florida Keys. The purpose of this study was to determine eligibility of the Florida Keys waters for designation as "Outstanding Florida Waters" (OFW). The evaluation of water quality focused on findings from previous studies as well as ambient water quality data collected from a special one-time sampling from 81 stations (49 ambient; 32 artificial waterways) on the oceanside of the Keys and from 84 stations (46 ambient and 38 artificial waterways) on the bayside of the Keys. Ambient stations were located approximately 1/4 mile offshore. Artificial waterways sampled included canals, boat basins and marinas adjacent to trailer parks, single and multiple family dwellings, and commercial operations.

Historical water quality surveys evaluated during this study are briefly summarized in Table 3.5. In addition to the studies listed, DER maintained a permanent monitoring station at John Pennekamp and secondary monitoring stations at Angelfish Creek, Lignumvitae, Bamboo Key, Wisteria Island, and Flamingo, from 1976 through 1985. DER summarized findings from these studies as follows (excerpted from DER, 1985):

1. Special studies done by various consultants, the state, and EPA have demonstrated that canal construction severely affects water quality, especially dissolved oxygen;

2. Point source dischargers have not been shown to be a major problem. However, trend data may show subtle effects when sampled for long periods;

3. Sources such as septic tanks and boreholes may significantly affect water quality;

4. Some studies of construction projects, such as the bridge replacement program, have not documented any post-construction water quality problems;

5. Several studies have pointed to a need for centralized wastewater treatment;

6. The available water quality data show few violations of water quality standards. However, the fragility of the coral reef and mangrove communities probably require stringent controls on pollution sources. Subtle changes in coral rings may reflect changes in water quality that are difficult to measure. Although large masses of water such as the Gulf Stream and Florida Current provide a buffer against rapid change by man, the long-term effects of road and other construction, boating and recreation, and sewage disposal require more study.

Results of the ambient water quality survey completed by DER in 1985 as part of the OFW designation study, are summarized as follows (Florida DER, 1985):

1. The overall water quality survey indicated that all the ambient waters in the Florida Keys met or exceeded the standards for Class III waters (as defined in Chapter 17-3, F.A.C.);

2. Waters within artificial waterways (canals, marina and boat basins), frequently appeared impacted and degraded;

3. The dissolved oxygen standard was the most frequently violated in the artificial waterways;

4. Bayside impact stations exhibited the highest number of DO violations, with 6 occurring at the surface, 6 at mid-depth and 8 at the bottom. (This represents a 17.6% and 23.5% occurrence in bayside artificial waterways, while ambient waters displayed zero violations);

5. Oceanside stations reflected similar results with no violations at ambient stations, while 4 surface, 6 mid-depth and 4 bottom measurements fell below the standard at impact stations;

6. A wider range of DO levels also occurred in artificial waterways, with some canals in compliance and others severely degraded. (DO levels of 0.0 mg/l were recorded at the Bahia Shores Subdivision canal station);

7. A majority of impact stations had higher levels of total phosphorus (P-TOT), total Kjeldahl nitrogen (TKN), ammonia (NH2+NO-3-N). (The highest recorded for any parameter was 1.150 mg/l TKN at the Lake Surprise Estates waterway station);

8. Normal ambient bayside TKN levels ranged between 0.128 and 0.693 mg/l; and

9. The mean values for all nutrient parameters of both bayside and oceanside impact stations were all significantly elevated above ambient stations.

DER, 1987d

In 1987, DER undertook an additional study of Florida Keys waters. The study was initiated to establish a water quality data base designed to assess the relative impacts of the following major pollution sources (Florida DER, 1987d):

1. Raw sewage and petroleum hydrocarbon discharges from boats, specifically live-aboard boats in marinas;

2. Discharge from seafood processors and commercial fishing operations, including wastewater, fish wastes, and waste oil from trap-dipping operations;

3. Discharges from stormwater collection systems;

4. Treated effluent from sewage treatment plants; and

5. Septic tank leachate through groundwater seepage.

Most of these sources throughout the Keys discharge into canals or enclosed basins and are not subject to rapid mixing with offshore waters (Florida DER, 1987d).

The goals of the monitoring study were (1) to assess the degree of water quality deterioration for each source; (2) to identify the cause(s) of that degradation; and (3) to recommend wastewater disposal solutions that would improve water quality, with particular consideration given to centralized wastewater treatment facilities in the Marathon area (Florida DER, 1987d).

A total of 32 water quality parameters were monitored at 12 stations for one year beginning in February 1984. Five primary stations were located at the discharge site of a pollutant source. Five secondary sites were situated in areas adjacent to the canal entrances of each corresponding primary station to monitor dilution of pollutant concentrations by open water. Two control stations were located in ambient waters one mile offshore.

Water quality monitoring results for the five sources were as follows (excerpted from DER, 1987d):

1. Faro Blanco Marina
   Water quality parameters which were significantly impacted in comparison with ambient conditions included DO, Ph, coliform bacteria, BOD, TKN, and total phosphorus.

Sediments in the marina basin also exhibited substantial accumulations of coprostanol, heavy metals, and petroleum hydrocarbons.

2. City Fish Market
The boat basin at City Fish Market experienced consistent severe deterioration of water quality due to discharges from the seafood processing plant and fishing boats. Only 5 of the 22 monitored parameters (temperature, suspended solids, nitrite, nitrate, and mercury) were not significantly impacted within the basin.

3. Winn-Dixie Stormwater Drainage System
The canal system receiving stormwater drainage from the shopping center parking lot suffered few of the impacts normally associated with input of contaminated stormwater. A partially occluded effluent pipe and inefficient drainage of the parking lot apparently minimized the amount of stormwater discharged to the waterway. Thus significantly degraded water quality parameters at the outfall were limited to DO, Ph, phosphorus, total coliform bacteria and heavy metals. Only Ph was significantly affected at the canal mouth.

4. Key Colony Beach Sewage Treatment Plant Outfall
No significant bacterial contamination or nutrient enrichment was apparent near the outfall, probably due to its location in an open, tidally influenced embayment. Those water quality parameters at the outfall that differed significantly from ambient conditions, did not severely stress environmental quality.

5. 90th Street Canal
The 90th Street canal suffers from fecal contamination and high levels of mercury, lead, zinc, copper, and hydrocarbons in the sediments. Iron levels, much higher than ambient levels, are indicative of septic tank leachate and stormwater runoff.

Lapointe and Clark, 1990a
Lapointe and Clark (1990a) described and analyzed the spatial and temporal variability in the existing trophic state of nearshore waters in Monroe County. The study was conducted between 9/12/89 and 9/19/90 at 30 sites throughout the nearshore waters of the County. Sites included six bank reef sites, four patch reef sites, seven seagrass/macroalgae meadows, 13 canal/contiguous bay sites. Sampling was designed to assess spatial variability of water quality within each site and thus to better detect potential nutrient impacts from adjacent land uses. At each site, three sampling stations were selected along a transect of variable length perpendicular to either the adjacent shoreline, canal system or reef system.

1. Variability in Dissolved Oxygen
Site accounted for most of the variability in dissolved oxygen, with typically higher values at the bank reef sites compared to lower values in nearshore waters, especially canal systems and seagrass beds of Florida Bay.

   Dawn DO concentrations were generally lower during the summer, when 13 out of the 30 stations (primarily developed canal sites and seagrass sites in Florida Bay) failed state standards for minimal DO concentrations.

Extremely hypoxic conditions (<1 mg/l DO) were observed during summer at Rabbit Keys, Flamingo, Garfield Bight, Glades Canal, Boot Key Harbor, Doctor's Arm and Ocean Shores.

2. Variability in Nutrients, Chlorophyll and Turbidity

   Site accounted for most of the variability in dissolved and particulate nutrient concentrations, with consistently low concentrations on the bank reef sites when compared to nearshore waters.

   Ammonium, nitrate plus nitrite, SRP and total dissolved phosphorous concentrations were elevated in developed canal sites and Florida Bay sites when compared to the reef bank sites.

   Higher concentrations of particulate carbon, nitrogen and phosphorous occurred in canals and Florida Bay sites, with generally higher values during winter.

   Higher concentrations of chlorophyll occurred in canals and Florida Bay sites, with generally higher values during summer.

   Turbidity was primarily affected by time and was much higher during winter.

3. Variability within Canal Sites

   In contrast to developed canals, undeveloped "sub pens" canal system has less than half the mean SRP concentration of the four developed canals and also had significantly greater DO.

   SRP concentrations at the "sub pens" were the same inside the canal system as at the adjacent station in OFW's, indicating no significant SRP enrichment within the canal.

4. Variability in Sediment Metals

   Metal concentrations in sediments varied significantly among stations, with concentrations of copper, iron, lead, zinc, and cadmium being highest in developed canal systems of the Keys and sites in upper Florida Bay.

Summary of Conclusions from Phase I of the Florida Keys National Marine Sanctuary Water Quality Protection Program

The Water Quality Assessment (Task 2) (CSA, 1991) completed for the Phase I FKNMS Water Quality Protection Program describes the point and non-point sources of pollutants and the status of water quality in the Sanctuary. Findings are based upon a review of the available scientific data and literature including the referred literature, Florida State agency reports, and examination of Florida and Federal Agency records. The summary of findings regarding the status of water quality taken from the Phase I study (Task 2) (CSA, 1991) is as follows:

> "The studies...of the water quality in the Florida Keys National Marine Sanctuary...indicate the relative paucity of data presently available to assess the water quality of the Keys. Insufficient data were available to demonstrate temporal changes in water quality because well designed, long-term studies have not been conducted.

Table 3.5

Summary of Water Quality Studies in the Florida Keys (1962 to 1985)

Florida State Board of Health (1962 and 1963)

Study evaluated 25 stations for bacteriological quality. Surveyed 45 stations in 1962 and 1963. Studies concluded:

1. Inshore tidal waters show significant pollution levels;
2. Normal methods of waste disposal were ineffective;
3. A general increase in bacteria levels at ebb and low tides indicated that polluted groundwater was leaching into shoreline waters;
4. The highest population levels were associated with the highest population densities; and
5. The subsurface soil was not filtering the effluent.

Schomer (1979)

Surveyed point source dischargers adjacent to outfalls. Surveyed facilities included Key Haven Utilities, Florida Keys Community College, Monroe County Public Service Building, Key Colony Beach and U.S. Navy Sigsbee Park. Water quality in receiving waters did not appear degraded near any discharge.

Magley (1982)

Intensive survey of NuAge Utilities and Safe Harbor Channel near Stock Island. Poorly flushed finger canals showed DO decreasing with depth. Some impact on water quality seen for nitrate and total phosphorus.

Evink (1981 (for Florida DOT)

Water quality studies in the area of Cross Key and Key Largo to measure impacts of causeways on water circulation and salinity. Concluded that little improvement in hypersaline conditions in Florida Bay would result if the existing causeways were modified.

Maturo and Caldwell (1981) (for Florida DOT)

Study to evaluate impact of bridge construction, dredging, piling emplacement, and tug and barge traffic. Elevated total phosphorus and nitrate levels found in dredge plumes. Values of DO generally above Class III standards, but some values occasionally below 4 mg/l. Turbidities usually below 10 NTU, except in dredge plume where values above 160 NTU found.

Continental Shelf Associates (1982) (for Florida DOT)

Looked at feasibility of replacing seagrasses along Craig Key that were damaged at numerous sites when Keys Bridges rebuilt. Survival rate of the seagrass did not appear to be related to ambient concentrations of ammonia, nitrate, nitrite, and levels of phosphorus, Eh, or pH in either surface level or root level of plants.

Florida DER (1982)

Monitored both field parameters and some nutrients in Dispatch Creek Basin. Many DO violations in the area (values as low as 0.1 mg/l) believed to be related to design of long, deep, and narrow canal systems which probably have limited circulation.

U.S. Environmental Protection Agency (1975)

Studied developed and undeveloped canal systems at Big Pine Key and Sea Air Estates in Marathon. Water quality parameters measured for different seasons. Dye studies on three canals to measure flushing times and dispersion rates.
Conclusions included:

1. DO violations were common at most canal stations, especially below depths of 4 to 6 feet;
2. DO usually decreased from the mouth toward the landward portion of the canals;
3. Septic tank studies indicated that leachates may not move rapidly if adjacent to finger canals at Big Pine Key;
4. Model simulations for canal flushing and wastewater assimilation were run for several different conditions indicating that wastewater flows with typical levels of effluent, even wastewater flows as low as 0.01 mgd were projected to suppress D.O. levels;
5. Violations of Class III standards for metals were not found at Big Pine Key for lead, manganese, or zinc;
6. One violation of the iron standard recorded and was attributed to runoff and leachates from septic tank drainfields;
7. Fecal and total coliform values did not violate standards in Big Pine Key;
8. Ammonia in developed canals in Big Pine Key (0.07 mg/l) higher than for undeveloped canals (0.04 mg/l). Other nutrients showed similar or no differences between the two systems; and
9. Marine grasses and algae carried into canals by winds or tides decompose and cause benthic demands.

CH2M Hill (1979)

Visual inspection of boreholes in the surrounding area showed limited horizontal migration of dye after two days. General assessment of water quality near septic tanks completed. See Table 3.6.

CH2M Hill (1983)

Study of biological and water quality impacts of Stock Island Power Plant. Quarterly sampling at several depths for temperature, D.O., pH, salinity, total sulfide, hydrogen sulfide, copper, iron and zinc. Largest impact found at mouth of discharge canal.

Source: Excerpted from Florida DER, 1985.

Table 3.6

Assessment of Environmental and Water Quality Sensitivity (1)

Location	Established or Probably Existing Problem	Probably Little or No Problem
Upper Key Largo		1,2,3,4,5,6
Key Largo City	1,2,3,4	5,6
Rock Harbor	1,2,3,4,5	6
Plantation	1,2,3,4,5	6
Tavernier	3,4	6
Windley Key	2,3,4	1,2,5,6
Upper Matecumbe	1,5	1,5,6
Lower Matecumbe	1,3,4	2,3,4,6
Layton/Long Key	1,2,3,4,5	2,5,6
Conch Key		6
Duck Key	4	1,2,3,4,5,6
Grassy Key	1,3,4,5	1,2,3,5,6
Crawl Key/Key Colony	1,2,3,4,5	2,6
Marathon	1,2,3,4,5	6
Big Pine Key	1,2,6	3,4,5
Little Torch Key	1	2,3,4,5,6
Ramrod Key	1,4	2,3,5,6
Summerland Key	1	2,3,5,6
Cudjoe Key	1,4	2,3,5,6
Upper Sugarloaf Key	4	1,2,3,5,6
Lower Sugarload Key	1,4	2,3,5,6
Saddlebunch Key (2)	1,2,4	3,5,6
Big Coppitt Key	1,2,3,4	5,6

(1) Environmental and Water Quality Criteria:
1. Prevalence of dead-end canals (poorly flushed, near septic tanks).
2. Prevalence of older septic tanks, cesspools, or raw sewage outfalls.
3. High population density.
4. Overall flushing to Gulf and Atlantic.
5. Known water quality contamination (EPA STORET, BC&E).
6. Developable fresh groundwater supplies.

(2) Includes populated areas of Saddlebunch Keys only.

Source: CH2M Hill, 1979.

Nearshore-offshore trends were very evident in all of the studies reviewed...Artificial waterways and canals in developed areas are subjected to nutrient load and the commensurate changes in increased organic matter and reduced dissolved oxygen concentration. For the most part, nearshore Outstanding Florida Waters are not subjected to the same level of nutrient loading as artificial canals and waterways. In areas of development, however, the data do indicate that some nutrient loading may be occurring. The studies reviewed do not indicate that offshore Outstanding Florida Waters are currently being subjected to degradation. Overall, the data indicate that areas that are well flushed (e.g., by exchange of water with the offshore oceanic region) tend to have good water quality. In nearshore areas where adequate flushing does not occur (i.e., areas subjected to anthropogenic influx or nutrients), the water quality tends to be poor.

This determination agrees with the water assessment performed by the DER as part of the 305(b) study (Florida DER, 1990b). During this study, water quality was examined through an inventory of the STORET data base for the period 1980 to 1989. It was determined that water quality in the Florida Keys was generally good in areas that were well flushed because of exchanges with the Gulf of Mexico and Atlantic Ocean. Reduced flushing, however, exacerbated water quality problems in many manmade canals and marinas."

3.5.3 Known Existing Point and Non-Point Source Pollution Problems

A. Point Sources Affecting Water Quality

Point sources of water pollutants are defined as wastewater discharges from facilities which flow directly into surface water. In unincorporated Monroe County these include sanitary wastewater treatment plants, water supply treatment plants and desalinization plants.

Inventory of Permitted Point Sources

All point sources are required to operate under a National Pollutant Discharge Elimination System (NPDES) Permit issued by the U.S. Environmental Protection Agency, pursuant to the Federal Clean Water Act. Most dischargers must also obtain a discharge permit from DER, pursuant to the Florida Air and Water Pollution Control Act. Due to the Outstanding Florida Water designation applicable to the Florida Keys (see Section 3.5.4 G below) it is very difficult to obtain a surface water discharge permit. Consequently most treatment facilities discharge into Class V injection wells (boreholes) and are considered non-point discharges (see Section 3.5.3 B below).

EPA data indicate that as of November, 1991, there were 23 NPDES dischargers in Monroe County (CSA, 1991)(Table 3.7). Twelve of the NPDES dischargers were located within unincorporated Monroe County, ten were within the City of Key West, and one was within the City of Key Colony Beach. All of the permitted wastewater facilities in the unincorporated County were minor dischargers which, with the exception of the Ocean Reef Club treatment plant, had fewer than 0.07 million gallons per day. All of the active discharges in the unincorporated County were domestic wastewater discharges. Two FKAA treatment plant permits were inactive at that time. No seafood processing operations discharged directly into surface waters in unincorporated Monroe County.

All permitted dischargers are required to submit monthly monitoring data to DER reporting various water quality parameters, typically including dissolved oxygen (DO), chlorine (total residual) and fecal coliform (CSA, 1991). None are required to monitor for nutrients (CSA, 1991).

Since 1974, there has been a steady decline in the number of permitted facilities discharging wastewater into surface waters in Monroe County. According to EPA data, the number of NPDES Permits dropped from 70 in 1974, to 35 at the beginning of 1991, to 23 in November 1991 (CSA, 1991). Discharges have been discontinued as a result of a combination of business closures, more stringent water quality standards recently adopted by DER, and/or permits for alternative disposal methods utilizing bore holes or septic systems (CSA, 1991). Of the remaining NPDES dischargers, several are planning to eliminate surface water discharge by connecting to an existing facility or discharging via injection wells or an on-site septic system (CSA, 1991).

B. Non-Point Sources Affecting Water Quality

Non-point sources of water pollutants are defined as discharges made directly or indirectly to overland flow or groundwater. In unincorporated Monroe County non-point sources include domestic wastewater (package treatment) facilities, on-site wastewater disposal systems, abandoned and inactive landfills, marinas, live-aboard vessels, application of mosquito control pesticides, and urban runoff.

Wastewater (Package Treatment) Facilities

DER records (1991) indicate that there are 185 wastewater treatment facilities with operating permits in unincorporated Monroe County (see Sanitary Sewer Chapter Table 10.4). These facilities provide wastewater treatment and disposal for schools, hospitals, restaurants, hotels/motels, trailer parks, campgrounds, condominiums, resort complexes, and shopping centers. Most of these dischargers are small package plants (Type III), having a typical capacity of from 10,000 to 20,000 gpd; the few larger facilities with average daily flows of from 40,000 to 75,000 gpd primarily serve resorts (CSA, 1991). Most facilities are operating at 20 to 40 percent of design capacity.

Package treatment plants in the Keys discharge to groundwater via Class V injection wells, referred to as boreholes. Boreholes range in depth from 18 to 27 m, with casing depth ranging from 9 to 18 m (CSA, 1991). DER now requires boreholes to be drilled to a depth of 27 m and cased to a depth of 18 m (CSA, 1991).

All permitted dischargers are required to submit monthly monitoring data to DER reporting various water quality parameters, typically including BOD, Ph, TSS, fecal coliform, and operational parameters. None are required to monitor for nutrients (CSA, 1991).

Currently there are 13 package treatment plants under some kind of enforcement action by DER. Legal action has been initiated in two cases where the permittee has not complied with the Consent Order.

DER has undertaken two studies to evaluate the impacts of borehole disposal of treated domestic effluent in the Keys. Merchant et al (1988) concluded that the secondarily treated domestic sewage being disposed of via Class V injection wells (boreholes) in the Keys is of relative good quality for disposal into Class G-III groundwater (CSA, 1991). This study did not address nutrient loading.

Table 3.7

Monroe County NPDES Point Source Flow and Constituent Data (reproduced from CSA, 1991)

ID #	Facility Name	Range of Max. Daily Flow (MGD)	Range of Daily Flow (MGD)	Range of BOD	Range of PH	Range of TSS
City of Key West						
2	Boyds Key West Campgrounds	No Data	0.005 - 0.016	4.0 - 7.0	7.27 - 7.53	3 - 21
201	FL Keys Community College	0.003 - 0.007	0.002 - 0.007	0.0 - 15.0	6.8 - 6.9	0 - 15
77	Key West STP	9.06 - 9.41	5.585 - 7.546	5.0 - 13.0	6.9 - 7.0	0 - 48
208	Key West Util - Stock Isl Steam	14.83 - 36.00	14.83 - 36.00	No Data Reported		
209	King Shrimp Company	Notified FDER on 11/15/91 of intent to cease operation				
199	Monroe Cnty Pub Ser Bldg	0.003 - 0.008	0.002 - 0.003	2.0 - 12.0	6.9 - 7.2	1 - 12
211	S&H Seafood - Key West	No EPA discharge monitoring report available				
212	USDA Animal Import Center	Only an emergency discharge point; has never been used				
205	USN Sigsbee Park STP	0.787 - 1.040	0.713 - 0.793	7.4 - 12.7	7.2 - 7.3	2 - 60
213	USN NAS Key West	Stormwater runoff permit for a fuel tank farm				
City of Key Colony Beach						
165	Key Colony Beach STP	0.2247 - 0.4990	0.135 - 0.195	2.0 - 11.0	6.9 - 7.0	4 - 80
Unincorporated Monroe County						
83	Fiesta Key KOA	0.0474 - 0.0568	0.005 - 0.016	4.0 - 7.0	7.27 - 7.53	3 - 21
206	FL Keys Aqueduct - Long Key	Discharge Monitoring Report indicates not in operation				
207	FL Keys Aqueduct - Ramrod Key	Discharge Monitoring Report indicates not in operation				
9	Geiger Key Marina	00.003 - 0.0110	0.001 - 0.003	2.0 - 17.0	6.9 - 7.1	1 - 20
77	Hawks Cay	0.049 - 0.069	0.033 - 0.057	1.0 - 8.0	6.8 - 7.2	2 - 50
210	Ocean Reef Club	0.666 - 0.752	0.287 - 0.411	0.1 - 1.05*	7.3 - 7.7	1 - 12
101	Caribbean Sunset Inn	0.005 - 0.011	0.002 - 0.005	1.0 - 4.0	6.9 - 7.1	2 - 12
113	UCSG Islamorada Station	0.003 - 0.0035	0.001 - 0.002	1.0 - 3.0	7.0	2 - 40
66	UCSG Marathon Station	0.0027 - 0.0067	0.001 - 0.005	4.0 - 13.0	6.9 - 7.2	3 - 12
176	USDA FWS Key Deer NWR	EPA discharge monitoring report available; discharge minor				
7	USN Boca Chica STP	0.127 - 0.516	0.0115 - 0.99	3.3 - 8.1	6.7 - 7.3	2 - 60
15	Venture Out in Am-Cudjoe Key	0.029 - 0.062	0.020 - 0.054	6.0 - 7.5	6.0 - 7.5	3 - 24

* Total Phosphorus

Sources: EPA 1991a; EPA 1991b; CH2M Hill 1979; G.Rios, pers. comm. 1991; M.Robertson, M. Donahue and R. Phelps, pers. comm. 1991.

MGD = million gallons per day

BOD = biological oxygen demand

TSS = total suspended solids

Outstanding questions remain regarding the effectiveness of nutrient removal from domestic wastewater by secondary package treatment plants and the impacts of nutrient loading on groundwater. Saarinen (1989) reports that typical removal efficiencies for secondary treatment were 10 to 20 percent of effluent concentrations for nitrogen and phosphorus (CSA, 1991). To address these concerns, DER initiated a long-term monitoring study in April, 1989, to more thoroughly determine the impact of domestic effluent discharges into boreholes (CSA, 1991). Data to date indicate that there has not been nutrient enrichment in and around the boreholes monitored in the study (CSA, 1991).

DER has notified 13 seafood processors in the Keys of the need to obtain industrial waste discharges and is reviewing permits for wastewater treatment systems to treat wastes from rhesus monkey breeding operations on Key Lois and Raccoon Key (FIMC, 1991).

On-Site Wastewater Disposal (OSDS) Systems

Approximately 65 percent of the wastewater flow in unincorporated Monroe County is treated by individual on-site disposal systems (OSDS). It is estimated that there are 24,000 septic tanks and 5,000 cesspits in the Florida Keys. The majority of these systems are conventional in-ground systems comprised of a septic tank and absorption field. Increasingly mound systems utilizing septic tanks are being installed. Approximately 184 aerobic units utilizing drainfields or injection wells have been permitted in unincorporated Monroe County.

Septic tank effluent contains varied concentrations of nitrogen, phosphorus, chloride, sulfate, sodium, toxic organics, detergent surfactants, pathogenic bacteria and viruses (CSA, 1991). OSDS effectiveness in removing these pollutants is directly related to soil conditions. All soils in the Keys, exclusive of Urban Land (which is largely developed) are rated by the U.S.D.A as having severe limitations for septic tank absorption fields (see Table 3.4) (U.S.D.A., 1989). Soils are generally constrained for absorption fields due to inadequate soil depth, flooding hazard, and wetness.

When properly installed and maintained, OSDS units can function adequately in the Keys in terms of fecal coliform and suspended solids removal as required by DER regulations in Chapter 10D-6, F.A.C. (CSA, 1991). However, there generally is inadequate soil to provide adequate purification of wastewater before it reaches groundwater (CH2M Hill, 1979). Porous rock-soil conditions combined with tidal influences work to reduce the effectiveness of septic tanks frequently to the degree that virtually untreated sewage can be leached into canal waterways (Snedaker, 1990).

No data or studies are available regarding effluent nutrient data for OSDS units. Additionally, there are very few studies that have investigated nutrient uptake by soils, movement of nutrients within groundwater and entry of these nutrients into nearshore waters (CSA, 1991). Conventional and mound systems are not designed to remove nutrients. Consequently only a minimal amount of nutrient reduction occurs through phosphorus absorption and precipitation in the natural soil system.

The treatment effectiveness of aerobic units has been studied by DER. From 1987 to 1980 DER monitored aerobic units in the Keys. Data indicated that many of the systems were not functioning in compliance with standards of the National Science Foundation (Burnaman, 1991; CSA, 1991). In addition aerobic units do not remove any nutrients from the waste stream (CSA, 1991).

Studies by Bicki et al (1984) and Lapointe et al (1990b) have researched the link between OSDS discharges and nearshore water pollution. Definitive conclusions concerning the exact relationship between septic tank effluent and nearshore water quality degradation have not been supported to date by findings of these studies (CSA, 1991).

Inactive Landfills and Abandoned Dumps

Monroe County does not have any active landfills receiving solid waste for on-site disposal. In December 1990, Waste Management Inc. (WMI) began to haul wet garbage, yard waste and construction debris out of unincorporated Monroe County. This service is being provided to the County under the terms of a five-year contract. The Monroe County Department of Environmental Management is planning for long-term disposal needs beyond 1997, investigating continued out-of-county disposal by WMI and various options for composting and pelletization.

In recent years prior to 1992, unincorporated Monroe County operated municipal landfills at Long Key Landfill, Cudjoe Landfill and Key Largo Landfill. Both the Long Key and Key Largo facilities operated under a DER Consent Order. All three facilities are now in the final stages of obtaining a DER closure permit. One small area at the Cudjoe Key Landfill has one area which meets the current requirements of Rule 17-701, F.A.C., and will remain open only to receive waste on an emergency basis. Under the current disposal arrangements with WMI, waste is still hauled by contracted collectors to the three landfill sites, dumped onto the tipping floor, and then collected, compacted and reloaded onto WMI trucks for transport out of the County.

In addition to the three inactive municipal landfill sites, EPA has identified five abandoned dump sites in Monroe County (EPA, date unknown). These include the following:

> <u>Boca Chica Key</u> (south US 1 SR 5, mile marker 8)
> Site owned by the U.S. Government. Operated as a landfill form 1947 to 1955. Currently part of the runway on the Naval Air Station;
>
> <u>Saddlebunch Key</u> (north US 1 SR 5, mile marker 15)
> Site owned by the U.S. Government. Operated by Bland Disposal as a landfill from 1957 to 1977. Currently vacant.
>
> <u>Middle Torch Key</u> (north US 1 SR 5, mile marker 27)
> Privately owned. Operated by Bland Disposal 1969 to 1978. Currently vacant.
>
> <u>Boot Key</u> (south US 1 SR 5, mile marker 48)
> Privately owned. Operated by Monroe County as a landfill 1951 to 1977.
>
> <u>Key Largo</u> (SR 905, four miles NE US 1 SR 5)
> Privately owned. Operated by Key's Sanitary Service as a landfill 1957 to 1980. Currently vacant.

None of the inactive county landfills or abandoned dump facilities had impervious liners put in place during their construction. Consequently there is the potential for downward migration of potentially hazardous leachate into the underlying strata. The underlying strata is either the Miami Oolite or Key Largo Limestone, both of which are highly porous and permeable and subject to saltwater intrusion and mixing (CSA, 1991). Leachate, when introduced to this type of substrate can migrate off-site through a number of subsurface cavities, fracture zones, or cavernous zones (CSA, 1991). Conditions favor the migration of materials that tend to upwell a considerable distance away (e.g., at an offshore location) (CSA, 1991).

Adequate data are generally not available to assess whether or not landfill leachate from any inactive county facilities is affecting nearshore water quality (CSA, 1991). The number of monitoring wells as well as their design and placement, appear to be insufficient to accurately monitor the percolation or migration of leachates through the landfills and into the groundwater (CSA, 1991). DER has completed one study of nearshore water quality adjacent to Long Key Landfill in which water samples were not found to be toxic (FIMC, 1991). Water samples analyzed by the U.S. FWS (U.S.D.I., 1991) for the inactive North Key Largo site indicated the presence of all heavy metals for which analyses were made at concentrations below the DER maximum contaminant level (Snedaker, 1990).

DER files are incomplete and there is insufficient monitoring data for abandoned landfills in Monroe County (CSA, 1991). The potential exists for these sites to have a detrimental effect on the nearshore water quality due to migration of landfill leachate. DER files do not identify monitoring wells for water quality assessments at any of these sites. EPA investigations have concluded that the potential for hazardous waste problems related to groundwater contamination at each of these sites is minimal (EPA, date unknown). Water samples analyzed by the U.S. FWS (U.S.D.I., 1991) for abandoned sites on North Key Largo and Saddlebunch Key indicated the presence of all heavy metals for which analyses were made, with all values within DER maximum contaminant levels except for one well where metal concentrations were greater than those in the Primary Drinking Water Standard (Snedaker, 1990).

Marinas

There are 183 marinas in unincorporated Monroe County, concentrated in Marathon, Islamorada, Key Largo, and Stock Island. Water quality in the vicinity of marinas is affected by general marina operations as well as by discharges from live-aboard vessels docked in marina slips. Some of the more potentially toxic or harmful materials associated with marinas include paints and wood preservatives containing copper and other heavy metals (Snedaker, 1990). Metal corrosion and oxidation represents an additional source of metal contamination due to the widespread use of zinc to protect boat hulls. Bilge waste is a source of oils, coolants, lubricants and cleaners. Live-aboard vessels generate an estimated 100 gpd of wastewater (DER, 1988b). Only three marinas in unincorporated Monroe County are equipped with pump-out facilities which are available for public use (Antonini et al., 1990).

Research suggests that toxic materials, which normally accumulate in organic bottom sediments, are more dispersed in nearshore marine environments such as are typical of the Keys where there is an absence of rich organic bottom sediments (Snedaker, 1990). Study of a marina in Marathon (Florida DER, 1987d) indicated that water quality was significantly impacted in comparison with ambient conditions based on dissolved oxygen, Ph, coliform bacteria, BOD, TKN, total phosphorus, copper and zinc. The presence and distribution of coprostanol in bottom sediments within and adjacent to the marina confirmed that the marina basin, particularly beneath boat slips, was acting as a sink for sewage contaminated water (Florida DER, 1987d). Water quality studies for Boot Key Harbor (Florida DER, 1990b) and Campbell's Marina on Key Largo (Florida DER, 1988b) have also linked marina activities to water degradation.

Live-Aboard Vessels
Live-aboard vessels are found throughout the nearshore waters of the Florida Keys. A 1989/1990 survey of live-aboards estimated that 274 live-aboard type vessels were anchored in the Keys, including Key West (Antonini et al., 1990). This estimate included vessels used for continuous overnight stays of at least two months. Most live-aboard vessels were tied up in marinas, although a sizable number were anchored offshore (Antonini et al., 1990).

Wastewater flows from live-aboard vessels have been estimated by DER at 100 gpd per boat (Florida DER, 1988b). Antonini (1990) reports that disposal of sanitary waste is by one or more methods: overboard by flushing, holding tank storage and subsequent shoreside pump-out, and/or on-board pretreatment and discharge. The mean sewage pretreatment capacity of live-aboard vessels in the Keys is about 30 percent reduction of sewage load BOD, roughly equivalent to a primary sewage treatment plant. (Antonini et al., 1990). The remaining 70 percent of the BOD load of sanitary waste is degraded in the adjacent receiving waters.

Seafood Processing Facilities
Seafood companies in Monroe County process an average of 25 million pounds of fish and seafood per year (Florida DER, 1987d; DNR 1977-1982). Wastes from processing operations include fish carcasses, cooking water, and wash-down water. When disposed of in nearshore waters or confined waters, these wastes result in organic loading and eutrophication, and consequent degradation of water quality parameters, including DO, Ph, BOD, turbidity, TKN, ammonia, total phosphorus, orthophosphate, chlorophyll a, and fecal and total coliform bacteria (Florida DER, 1987d). The impact is exacerbated when wastes are discharged into artificial waterways where restricted circulation maximizes the accumulation of contaminants (Florida DER, 1987d; EPA 1975).

Few of the seafood processing facilities in the Keys operate under DER Industrial Waste Permits and are therefore not subject to discharge limits and enforcement actions. None currently have NPDES permits. DER has notified 13 seafood processors of the need to apply for industrial wastewater permits (FIMC, 1991).

Application of Mosquito Control Pesticides
The Monroe County Department of Health and Rehabilitative Services conducts year-round aerial applications of pesticides for mosquito control. These applications are a source of atmospheric and land-based non-point loading on the Florida Keys environment (CSA, 1991).

Most applications are limited to areas surrounding residential communities, commercial and light industrial site locations, within the boundaries of the County's inactive landfills, and within areas of standing water (CSA, 1991). Applications are restricted on most conservation lands owned by the state and federal governments, particularly on North Key Largo due to the presence of the federally-designated endangered Schaus' swallowtail butterfly.

The most commonly used insecticides (by tradename) include (CSA, 1991):

Dibrom 14C	Malathion	Teknar
Acrobe	Biomist 4 + 12	Bactimos
Abate	Altosid	Bectobac
Ortho Additive	Artosurf	Scourge
Diesel Oil	Fyntex	Fog Oil.

Material Safety Data Sheets from the Pesticide Information Office of the Florida Cooperative Extension Service indicate that many of these chemicals are toxic to fish, aquatic life and/or wildlife and should not be applied directly to water (CSA, 1991).

To date, there have been no in-depth toxicological studies that correlate mosquito spraying with deterioration of environmental systems in the Keys (CSA, 1991).

Urban Runoff

Non-point source contamination of nearshore waters in the Keys by urban runoff is meliorated by the small area of developed land in Monroe County in relation to the surrounding water area, and by the natural permeability of the underlying limestone (Florida DER, 1987d). However, despite these conditions researchers warn that given the low assimilation threshold of oligotrophic waters, the potential impacts on non-point source loading from urban runoff should be recognized (Snedaker, 1990). Some evidence suggests that when stormwater discharges are located in artificial waterways, contamination from runoff can be magnified, with the result that even minor inputs may become harmful over extended periods (Florida DER, 1987d). Water quality parameters which are typically degraded in areas receiving contaminated stormwater include DO, Ph, phosphorus, total coliform bacteria, heavy metals, and petroleum hydrocarbons.

SFWMD currently permits 58 stormwater dischargers in unincorporated Monroe County (see Drainage Chapter Table 11.1). These permits are for projects involving more than 40 acres. They have been issued by SFWMD primarily for highways, residential developments and commercial centers.

C-111 Canal and Model Land Canal

The C-111 is the southernmost canal of the C&SF Project, completed in 1967 and operated by the SFWMD. The C-111 drains agricultural areas in South Dade County and discharges into Manatee Bay (Barnes Sound) west of Key Largo. The canal functions are: to supply water to the eastern panhandle of Everglades National Park; to prevent saltwater intrusion, and; to provide flood protection for upstream agricultural uses (SFWMD, 1991). Large episodic releases of freshwater have occurred from the C-111 basin into Card Sound and Barnes Sound. These releases have been due to the periodic removal of the S-197 structure from the mouth of the C-111 Canal to alleviate upstream flooding (SFWMD, 1991). They have had severe impacts on marine biota and may have impacted water quality in the estuary due to the potential presence of suspended sediments containing contaminants from the urban and agricultural areas of south Dade County (SFWMD, 1991). These impacts are exacerbated by the tendency of large volumes of freshwater to move as discrete parcels and by the restricted circulation and increased residence time of water in Card Sound and Barnes Sound.

The Model Land Canal has a connection to Card Sound consisting a length of canal terminating at a culvert (CSA, 1991). No water quality data are available for the canal (CSA, 1991).

Hazardous Wastes and Hazardous Materials

Hazardous waste sites and hazardous materials are addressed below in Section 3.17. The discussion addresses:

(a) hazardous waste disposal sites;
(b) hazardous waste generators;
(c) household hazardous wastes;
(d) underground and aboveground storage tanks; and
(e) terrestrial and marine hazardous material spills.

Included is a brief inventory of existing hazards and incident reports as well as a brief summary of soil, groundwater and/or surface water quality monitoring studies for specific sites where hazardous waste contamination has occurred.

C. External Sources of Pollutant Loads

Natural and man-made sources of poor water quality affect waters of the FKNMS, including increased turbidity or suspended solids, temperature changes, increased nutrients, salinity changes or increased levels of heavy metals, synthetic organic chemical, and anthropogenic organic chemicals (CSA, 1991).

Florida Bay
Water quality in Florida Bay is highly variable depending upon prevailing weather and climatic conditions (Schomer and Drew, 1982; SFWMD, 1991) and is generally the result of natural causes (CSA, 1991). Causes of poor water quality include wind-driven transport of suspended particulates; the presence of soluble nutrients; decomposition; transport of mangrove detritus; seagrass decomposition with associated biologic activity; and naturally-occurring low dissolved oxygen at night attributed to plant respiration (CSA, 1991). The Bay has shown no indications of a prevalent anthropogenic with contaminants other than freshwater (Schomer and Drew, 1982; SFWMD, 1991). Elevated nutrients in the Bay have been documented, largely due to seagrass die-off, the causes of which have not been determined (CSA, 1991).

Biscayne Bay
Biscayne Bay is a potential source of poor water quality to the FKNMS due to flows of various types from the City of Miami, other local municipalities, and Metro-Dade County (CSA, 1991). North Biscayne Bay, extending from Dumfounding Bay to Rickenbacker Causeway, is contaminated by large numbers of anthropogenic sources including manufacturing, boat building and repair, urban runoff, raw sewage from illegal connections, degraded systems and overflows during heavy rains (CSA, 1991). The Miami River has the poorest water quality in Biscayne Bay (CSA, 1991). Offshore disposal of dredged Miami River sediments may potentially have detrimental effects on the reef tract due to longshore transport from the north (CSA, 1991). The Metro-Dade County offshore sewage outfall, discharges treated sewage in 30 m of water off Miami Beach. The potential exists for effluent from this outfall to affect waters in the Keys (CSA, 1991). South Bay, extends from Rickenbacker Causeway to Arsenicker Keys. External pollutant loads, other than extremely fresh or extremely saline water, from this area to waters of the Keys are most likely low due to less urban development, presence of only a few external sources of contamination, extreme residence times, and restricted circulation (CSA, 1991).

D. Other Water Quality Issues

Unplugging Artificial Canals
Several artificial canals in the Keys have been plugged to prevent connections to open water. Generally these plugs have been placed by the COE because dredging occurred in violation of a permit or without a permit. In some, water quality conditions have deteriorated due to excessive depths (frequently as much as 20 feet), nutrient loading from adjacent on-site disposal systems, and lack of flushing. Residents along many of these canals seek relief from DER and COE, requesting that the canals be opened. In a limited number of cases, the COE has permitted opening of plugged canals where water quality in the canals meets the standards of the water outside the canal. Typically, unplugging requires backfilling the canal to depths of from four to six feet. Dredging is not permitted in conjunction with unplugging.

DER and the County should work cooperatively to assess the water quality issues related to opening of artificial canals, and to reach consensus on the appropriateness of opening versus continued plugging of artificial canals in the Keys.

Use of Aerators in Artificial Canals
Poor water quality in artificial canals in several areas of the Keys has led residents to request permits from DER for installation of aerators. Further study of the benefits and adverse impacts associated with the use of aerators in artificial canals is needed, including evaluation of alternative aerator technologies.

DER and the County should work cooperatively to address this issue, and to reach consensus on the appropriateness of aerator use and the conditions under which aerators will be permitted in the Keys.

Shoreline Setbacks
Monroe County currently prohibits uses within a shoreline setback which will have an adverse water quality impact. The County Biologist is responsible for making this determination. Where no adverse water quality impacts are anticipated from a proposed activity within a shoreline setback, it can be permitted provided that it does not have associated with it more than 100 square feet of impervious surfaces or any structures which are more than 8 inches above the ground surface.

DCA and the County should work cooperatively to address possible revisions to these regulations. Particularly there is a need for a finding of intent, clarification of permitted uses within the shoreline setback, and design criteria for structures within the shoreline setback.

3.5.4 Actions Needed to Protect Water Quality/State, Regional and Local Regulatory Programs which will be Used to Maintain or Improve Water Quality/Potential for Conservation, Use or Protection of Water Resources

A. Florida Keys National Marine Sanctuary Water Quality Protection Program

The Florida Keys National Marine Sanctuary (FKNMS) was established on November 16, 1990 with signing of the Florida Keys National Marine Sanctuary and Protection Act (Public Law 101-965) by President Bush. The purpose of this act is "to protect the resources of the [FKNMS] to educate and interpret for the public regarding the Florida Keys marine environment, and to manage such human uses of the [FKNMS] consistent with [the] Act."

The FKNMS consists of all submerged lands and waters, along with all the living marine and other resources within and on those lands and waters, from the mean high water mark to the offshore sanctuary boundary described in Public Law 101-965, generally lying at the 300-foot depth contour line. Included within this designated area are approximately 2,600 square nautical miles of nearshore waters extending from just south of Miami to the Dry Tortugas. Excluded from the FKNMS are Everglades National Park, Biscayne National Park, and Fort Jefferson National Monument. On December 18, 1990, the Governor and Florida Cabinet, passed a resolution to include State lands and resources within the boundary of the FKNMS, subject to certain provisions which retained state ownership and management responsibilities of state-owned land until completion of the FKNMS Comprehensive Management Plan (see below). The FKNMS encompasses all of the nearshore and confined waters of Monroe County.

The U.S. Department of Commerce, National Oceanographic and Atmospheric Administration (NOAA), is charged with responsibility for developing a comprehensive management plan and implementing regulations to achieve the policy and purpose of Public Law 101-965. Public Law 101-965 states that the FKNMS Comprehensive Management Plan shall:

(a) "facilitate all public and private uses of the Sanctuary consistent with the primary objective of Sanctuary resource protection;

(b) consider temporal and geographical zoning, to ensure protection of sanctuary resources;

(c) incorporate regulations necessary to enforce the elements of [a] comprehensive water quality protection program...unless the Secretary of Commerce determines that such program does not meet the purpose for which the Sanctuary is designated or is otherwise inconsistent or incompatible with the comprehensive management plan...;

(d) identify needs for research and establish a long-term ecological monitoring program;

(e) identify alternative sources of funding needed to fully implement the plan's provisions...;

(f) ensure coordination and cooperation between Sanctuary managers and other Federal, State, and local authorities with jurisdiction within or adjacent to the Sanctuary;

(g) promote education, among users of the Sanctuary, about coral reef conservation and navigational safety; and

(h) incorporate the existing Looe Key and Key Largo National Marine Sanctuaries into the [FKNMS] except that Looe Key and Key Largo Sanctuaries shall continue to be operated until completion of the comprehensive management plan for the [FKNMS]."

The U.S. Environmental Protection Agency and the State of Florida, in consultation with NOAA, are charged with responsibility for developing a comprehensive water quality management program for the FKNMS. Public Law 101-965 states that the FKNMS Water Quality Management Program shall provide for measures to achieve the purposes of the program, including:

(a) "adoption or revision, under applicable Federal and State laws by the State and [EPA] of applicable water quality standards for the Sanctuary, based on water quality criteria which may utilize biological monitoring or assessment methods to assure protection and restoration of the water quality, coral reefs, and other living marine resources of the Sanctuary;

(b) adoption under applicable Federal and State laws of enforceable pollution control measures (including water quality-based effluent limitations and best management practices) and methods to eliminate or reduce pollution from point and non-point sources;

(c) establishment of a comprehensive water quality monitoring program to:
  (i) determine the sources of pollution causing or contributing to existing or anticipated pollution problems in the Sanctuary,
  (ii) evaluate the effectiveness of efforts to reduce or eliminate those sources of pollution, and
  (iii) evaluate progress toward achieving and maintaining water quality standards and toward protecting and restoring the coral reefs and other living marine resources of the Sanctuary;

(a) provision of adequate opportunity for public participation in all aspects of developing and implementing the program; and

(b) identification of funding for implementation of the program, including appropriate Federal and State cost sharing arrangements."

NOAA is currently developing the FKNMS Comprehensive Management Plan. Completion of the Plan and Environmental Impact Statement, pursuant to the National Environmental Policy Act, is expected by July/August 1993. The U.S. EPA and the State of Florida, through the Interagency Management Committee, are developing the Water Quality Protection Program, schedule for completion by July 1992. The Monroe County Department of Marine Resources is working cooperatively with NOAA, EPA and the State of Florida on the development and implementation strategies for both management plans.

Phase I of the Water Quality Protection Program is undergoing final revisions. Draft findings are documented in the following publication:

Continental Shelf Associates. 1991. Water quality protection program for the Florida Keys National Marine Sanctuary: Phase 1 report (draft). U.S. Environmental Protection Agency, Atlanta, GA.

The Phase I Report (CSA, 1991) includes assessments of trends and problems related to water quality, the coral community, submerged and emergent aquatic vegetation, nearshore and confined waters, and spills and hazardous materials. Phase II will evaluate and recommend institutional and structural actions to be included in the final Water Quality Protection Program. Phase II will be completed by July 1992.

As required by Public Law 101-965, the FKNMS Water Quality Protection Program shall be a coordinated effort of Federal, State and local regulatory agencies designed to protect the living marine resources and waters of the Florida Keys. This program shall address in a comprehensive fashion the many water quality issues in the region. Monroe County will continue to work cooperatively in development and implementation of both the FKNMS Water Quality Protection Program and the FKNMS Comprehensive Management Plan. The County's responsibilities for implementation of specific elements of the plan shall be the subject of future interagency and intergovernmental agreements between Monroe County and Federal, State and Regional agencies. Future studies undertaken by Monroe County related to upland activities and land uses potentially affecting water quality shall be designed and implemented in a manner consistent with the purpose of Public Law 101-965 and recommendations of both the FKNMS Comprehensive Management Plan and FKNMS Water Quality Protection Program.

Monroe County policies regarding implementation of the FKNMS Water Quality Protection Program are included under Goal 202 and Goal 203 of the Year 2010 Comprehensive Plan Policy Document.

B. Need for Ambient Water Quality Monitoring Program and Special Water Quality Studies

Phase I of the FKNMS Water Quality Protection Program (CSA, 1991) concludes that there is a lack of data documenting a decline in water quality in the offshore and nearshore waters of the FKNMS and further states that there is no documentation that the perceived declines in coral communities and seagrass beds in the Keys are linked to water quality. Several recommendations are made relative to the development of the FKNMS Water Quality Protection Plan which will provide data to document these relationships as well as to provide the basis for institutional and regulatory changes which will protect against further declines in the quality of confined and nearshore waters and their biotic communities (CSA, 1991). These include (CSA, 1991):

(a) develop a monitoring plan to characterize the nutrient inputs to the groundwater;

(b) develop a research plan to collect data and model the transportation of groundwater nutrients to marine coastal waters;

(c) develop a monitoring plan to characterize the constituents within stormwater in the Florida Keys based on use...[and]...determine what percentage of stormwater results in overland flow to marine coastal waters;

(d) develop a research plan to collect data on natural nutrient regeneration due to decomposition of floating <u>Sargassum</u> and seagrass within confined water bodies;

(e) evaluate the relative contributions of point source discharges, groundwater input, stormwater overland flow, natural decomposition of organic matter, and other mechanisms (e.g., rainfall) to nutrient input and potential of further declines in water quality within the confined waters of the FKNMS;

(f) develop for confined and nearshore waters a water quality monitoring program for water sediment and biotic parameters;

(g) select representative areas of confined waters that are experiencing poor water quality and develop potential engineering solutions...[, with cost estimates, applicable to all of the Florida Keys]; and

(h) coordinate all of the tasks with other government entities with jurisdiction in the Florida Keys...[with particular coordination to]...be maintained with Monroe County's development of proposed Sanitary Wastewater and Stormwater Master Plans as well as the National Oceanic and Atmospheric Administration (NOAA) plans for research initiatives.

Programs for these studies will be developed as part of the FKNMS Water Quality Protection Program. Federal and State agency and local governments responsibilities for execution of these studies will be the subject of memoranda of agreements. All parties involved are seeking to enter into these agreements by July/August, 1993.

Monroe County policies regarding participation in these studies are included under Objective 202.1 of the Year 2010 Comprehensive Plan Policy Document.

C. Surface Water Improvement Management Plans

In 1987 the Florida Legislature enacted the Surface Water Improvement and Management (SWIM) Act. The SWIM Act requires each of the State's water management districts to design and implement plans and programs for the improvement and management of surface waters for priority water bodies. Priority water bodies within Monroe County or influencing estuaries of Monroe County include Biscayne Bay and the combined waters of Everglades National Park (ENP) and the Water Conservation Areas (WCA's). Water quality issues related to these two priority water bodies affecting Monroe County waters are associated with the timing and distribution of discharges from freshwater areas into the marine estuaries of Florida Bay, Manatee Bay and Barnes Sound (SFWMD, 1991).

The SWIM Plan for Biscayne Bay (SFWMD, 1989) has been in effect for several years. SFWMD is currently in the beginning stage of a plan revision which will incorporate findings from new studies and new plans. Final adoption of the revised Biscayne Bay SWIM Plan is anticipated in 1993 (SFWMD, Robert Kral, personal communication).

The SWIM Plan for the Everglades (SFWMD, 1991) is undergoing final review by DER for consistency with the State Comprehensive Plan (Chapter 187 F.S.) and the State Water Policy. Final adoption of the Everglades National Park SWIM Plan is anticipated by the end of 1992 (SFWMD, Jason Duff, personal communication). The SWIM Plan includes several C-111 Basin hydroperiod improvements designed to: reduce freshwater impacts on Manatee Bay/Barnes Sound/Florida Bay associated with C-111 discharges; improve distribution of water resources to Taylor Slough and the Everglades National Park Panhandle; and to reestablish sheet flow over existing wetlands.

Monroe County policies regarding county participation in future revisions to the SMIM plans for Biscayne Bay and Everglades National Park are included under Objective 202.16 of the Year 2010 Comprehensive Plan Policy Document.

D. Florida Keys Advance Identification of Wetlands (ADID) Program

The Florida Keys Advance Identification of Wetlands (ADID) Program is a joint effort of the EPA, FWS, COE, SFWMD, FGFWC and Monroe County. The ADID program is designed to facilitate the permitting process under Section 404 of the Clean Water Act of 1973 by providing comprehensive wetlands mapping and assessment information. The scope of the ADID Program includes the entire Florida Keys, prioritized as follows:

(a) privately-owned lands with development potential on the islands connected by US 1;

(b) publicly-owned lands on the islands connected by US 1; and

(c) offshore islands (which appear in imagery of the islands connected by US 1).

Monroe County will utilize data obtained from the ADID Program to refine its Land Development Regulations (Monroe County BOCC, 1990) and wetlands permitting activities to eliminate the loss of undisturbed wetlands and to eliminate the net loss of disturbed wetlands. This will further protect the important water quality, shoreline stabilization and flood control functions of marine and upland wetlands in the Keys.

Monroe County policies regarding county participation in the ADID Program are included under Goal 204 of the Year 2010 Comprehensive Plan Policy Document.

E. Coastal Barriers Resources Program

The Coastal Barrier Resources Act (CBRA) of 1982 established the Coastal Barrier Resources System (CBRS). Today, the CBRS is comprised of undeveloped coastal barriers along the Atlantic and Gulf of Mexico coasts, including the coasts of the Florida Keys, Puerto Rico and the Virgin Islands. The CBRS includes fifteen units located within the Florida Keys. Table 3.21 in Section 3.18 below identifies the Keys' CRBS units (listed under the category of "marine resource areas of particular concern"), describes the general environmental protection measures provided by the COBRA program by the Federal Government, and the actions to be taken by Monroe County consistent with the intent of the COBRA program.

Monroe County policies regarding protection of CBRS units are included under Objective 102.8 of the Year 2010 Comprehensive Plan Policy Document.

F. Monroe County Programs, Plans and Special Studies which Protect Water Quality

Monroe County Department of Marine Resources

The Monroe County Department of Marine Resources (DMR) was established in 1991. The Department's mission is (Monroe County DMR, 1991):

> "to assist in the protection, conservation and/or restoration of the marine resources and waters of the Florida Keys, as well as, to help provide for adequate and appropriate recreational and commercial use of the Keys' marine environment."

The principal directions of the DMR are summarized as follows (Monroe County DMR, 1991):

(a) serve in the role of liaison to the state and federal government in the preparation of the FKNMS Management Plan;

(b) work on completion, update, and/or revision of the Monroe County Year 2010 Comprehensive Plan as it related to the marine environment;

(c) seek grant funding for research in the areas of the marine sciences and resource management;

(d) provide input and any necessary assistance on specified matters relating to recreational and commercial marine fisheries in the Keys;

(e) provide input and necessary assistance in the improvement of the recreational and commercial boating environment in the Keys; and

(f) assist in the completion of a Geographic Information System (GIS) which accurately depicts the shoreline, marine and upland environment, and common physical map features in the Keys.

Monroe County policies regarding the Department of Marine Resources are included under Objective 202.1 of the Year 2010 Comprehensive Plan Policy Document.

Monroe County Year 2010 Comprehensive Plan - Level of Service Standards for Sanitary Wastewater Treatment and Stormwater Discharges

Interim level of service standards established for wastewater treatment and stormwater discharges are identified in the Sanitary Sewer Chapter and Drainage Chapter of the Comprehensive Plan. These are summarized as follows:

<u>Package Treatment Plants:</u>
The interim level of service for these facilities for quantity and quality will be determined as a percent of design capacity and the ability of the wastewater treatment plant to meet the effluent quality and operational standards set forth in Chapter 17-600, F.A.C.

<u>On-Site Disposal Systems (OSDS):</u>
On-Site Disposal Systems shall be in compliance with the most recent requirements of Chapter 10D-6 Part 6, Part II, F.A.C.

Stormwater Discharges:
Development shall ensure that stormwater discharges will meet state water quality standards as set forth in Chapter 17-25, F.A.C.

Stormwater Discharge: Retention/Detention Criteria

(a) Retention and/or detention in the overall system, including swales, lakes, canals, greenways, ets., shall be provided for one of the three following criteria or equivalent combinations thereof:

    (1) wet detention volume shall be provided for the first inch of runoff from the development project, or the total runoff of 2.5 inches times the percentage of imperviousness, whichever is greater;
    (2) dry detention volume shall be provided equal to 75 percent of the above amount computed for wet detention; and/or
    (3) retention volume shall be provided equal to 50 percent of the above amounts computed for wet detention.

(b) Stormwater discharge facilities which discharge directly to Outstanding Florida Waters shall include an additional 50 percent of the water quality treatment specified in section a above.

The Comprehensive Plan calls for revision to these interim levels of service following completion of the Sanitary Wastewater Management Plan and the Stormwater Management Plan as outlined in Sections 10.4 and 10.5 of the Sanitary Sewer Chapter and Section 11.6 of the Drainage Chapter. The expectation is that the revised LOS standards will establish more stringent nutrient effluent limitations for all wastewater flows.

Monroe County Year 2010 Comprehensive Plan - Water Quality Protection Goals, Objectives and Policies

The Comprehensive Plan includes goals, objectives and policies (GOP's) to reduce pollutant discharges into ground and surface waters from point and non-point sources. These GOP's outline the specific actions to be taken by Monroe County to protect estuaries and nearshore waters. They are found under Goal 202 of the Year 2010 Comprehensive Plan Policy Document. Policies are included which address water quality impacts from:

(a) on-site disposal systems;
(b) secondary sewage treatments plants;
(c) live-aboard vessels;
(d) marinas and fueling facilities;
(e) seafood processing facilities;
(f) recreational boating;
(g) dredge and fill operations;
(h) stormwater runoff;
(i) erosion and sedimentation;
(j) pesticide applications;
(k) aboveground and underground storage tanks; and
(l) hazardous wastes.

Also included are policies regarding the County's participation in studies and programs resulting from the FKNMS Water Quality Protection Program, the County's participation in the SWIM Planning Process, and special investigations regarding water quality in artificial canals and plugged waterways.

Monroe County Land Development Regulations
The Monroe County Land Development Regulation (LDR's) (Monroe County BOCC, 1990) include numerous regulations pertaining to activities potentially affecting water quality. These are as follows:

Section 9.5-262		Maximum residential density and district open space
Section 9.5-286		Shoreline setback
Section 9.5-288		Bulkheads, seawalls, riprap and fences
Section 9.5-293		Surface water management criteria
Section 9.5-293.1		Revision of surface water management criteria
Section 9.5.294		Wastewater treatment criteria
Section 9.5-305		Water supply and sanitary sewer service
Section 9.5-308		Live-Aboards
Section 9.5-343		Open space requirements
Section 9.5-345		Environmental design criteria
9.5-345(b)	-	salt marsh and buttonwoods
9.5-345(l)	-	beach-berm complex
9.5-345(m)	-	mangroves and submerged lands
9.5-345(n)	-	freshwater wetlands
9.5-345(o)(3)	-	disturbed land with beach-berm
9.5-345(o)(4)	-	disturbed land with salt marsh and buttonwoods.

In addition to the LDR's, Monroe County regulates the following activities potentially affecting water quality:

(a) Monroe County Ordinance No.029-1989 regulates the sale or furnishing of detergents, specifically aimed at reducing phosphate loadings into wastewater flows;

(b) Monroe County policies pertaining to dredging are included in the Florida Keys' Comprehensive Plan (Monroe County Planning Dept., 1986b); and

(c) erosion and sedimentation control requirements are attached as conditions of Development Orders.

Many revisions to the LDR's pertaining to activities potentially affecting water quality shall be adopted by Monroe County by September 30, 1995. These are detailed in the Goals, Objectives and Policies of the Year 2010 Comprehensive Plan Policy Document.

Special Plans and Studies to be Completed by Monroe County
Several special plans and studies are either ongoing or planned in the next few years by Monroe County. Several of these will provide background data, identification of trends and problems, and

recommendations for regulatory and policy revisions related to specific land uses which affect water quality.

Studies Examining the Nearshore and Confined Water Environment
Monroe County shall coordinate with EPA, DER, SFWMD and NOAA to determine the scope of studies required to document pollutant loads for Florida Keys waters. By June 30, 1993, the County shall seek to enter into an agreement with these agencies which shall describe the responsibilities of each agency and of the County in the identified studies. The scope of the Sanitary Wastewater Management Plan (see below), the Stormwater Management Master Plan (see below), and the Live-Aboard Study (see below) shall be developed so as to include special studies to assess pollutant loadings from these sources. Monroe County policies regarding water quality monitoring and assessment studies are included under Objective 202.1 of the Year 2010 Comprehensive Plan Policy Document.

Sanitary Wastewater Master Plan
By September 30, 1995, Monroe County shall prepare a Sanitary Wastewater Master Plan (SWMP) to determine the required levels of service and type of treatment for all developed and undeveloped areas in Monroe County. The scope of the SWMP is presented in the Sanitary Sewer Chapter. Monroe County policies regarding the SWMP are included under Objective 901.4 of the Year 2010 Comprehensive Plan Policy Document.

Stormwater Management Master Plan
By September 30, 1995, Monroe County in coordination with SFWMD and DER shall complete a comprehensive Stormwater Management Master Plan (SMMP) which ensures that stormwater management facilities are developed to attain adopted levels of service for all existing and proposed land use. The scope of the SMMP is presented in the Drainage Chapter. Monroe County policies regarding the SMMP are included under Objective 1001.3 of the Year 2010 Comprehensive Plan Policy Document.

Live-Aboard Study
Monroe County shall develop and implement siting and discharge regulations, fee requirements and enforcement provisions designed to reduce pollutant discharges into surface waters from moored/anchored vessels (live-aboards) in nearshore waters. By September 30, 1993, the County shall complete a report concerning live-aboard vessels which will be the basis of revisions to the Land Development Regulations regarding live-aboards. Monroe County policies regarding live-aboards are included under Objective 202.4 of the Year 2010 Comprehensive Plan Policy Document.

Marina Survey and Development of Marina Siting Criteria
By September 30, 1993, Monroe County shall complete an analysis of the need for additional marina facilities and shall develop criteria for marina siting which shall meet or exceed state standards. Monroe County policies regarding marinas are included under Objective 202.5 and 212.4 of the Year 2010 Comprehensive Plan Policy Document.

Boating Management Plan
By September 30, 1993, Monroe County in cooperation with DNR shall develop and implement a boating impacts management program. Monroe County Policies regarding

boating impacts management are included under Objective 203.5 of the Year 2010 Comprehensive Plan Policy Document.

Freshwater Lens Study

By September 30, 1994, Monroe County shall map the freshwater lens systems and associated recharge areas in the Florida Keys and shall adopt regulations which protect the lenses from loss of recharge potential and from threats of groundwater contamination. The scope of the freshwater lens study is presented in the Natural Groundwater Aquifer Recharge Chapter. Monroe County policies regarding the SMMP are included under Objective 1101.2 of the Year 2010 Comprehensive Plan Policy Document.

G. Federal, State and Local Regulatory Programs Protecting Water Quality

Applicable State Water Quality Standards

The Florida Department of Environmental Regulation has classified the nearshore waters of Monroe County as follows:

Class II Waters: Shellfish Propagation or Harvesting

From Collier and Dade County Lines southward to and including that part of Florida Bay within Everglades National Park.

Class III Waters: Recreation - Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife.

All others waters of the State in Monroe County not classified as Class II Waters.

Water quality criteria for Class II and Class III waters are set forth in Chapters 17-3.111 and 17-3.121, F.A.C., respectively.

In recognition of the exceptional ecological and recreational significance of the waters of the Florida Keys, DER has further designated most of the waters of the County as "Outstanding Florida Waters (OFW)", including the following:

(a) Waters within Biscayne National Park and Everglades National Park;

(b) Waters within Bahia Honda State Recreation Area, John Pennekamp Coral Reef State Park, and Long Key State Recreation Area;

(c) Waters within Lignumvitae Key State Botanical Site and Mahogany Hammock State Botanical Site;

(d) Waters within Biscayne Bay - Card Sound Aquatic Preserve, Coupon Bight Aquatic Preserve, and Lignumvitae Aquatic Preserve; and

(e) All Class III water of the County, excluding the following three areas:

(1) Key West Sewage Outfall (being a circle 150 feet in radius from the point of discharge);
(2) Stock Island Power Plant (being a circle 150 feet in radius from the end of the power plant discharge canal; and
(3) Artificial waterbodies, defined as any waterbody created by dredging, or excavation, or by filling in of its boundaries, including canals as define in Section 17-12.020(1), F.A.C. (5-8-85).

Current Class II and Class III standards allow DER to legally issue permits for activities that would lower water quality to the minimum for the water quality classification. The OFW designation, while retaining the Class III standards, prohibits any human activity or discharge which will degrade the existing ambient water quality.

State Regulatory Programs which will be used to Protect Water Quality
Specific state policy guidance and rules pertaining to protection of water quality are found in several sections of the Florida Administrative Code. These include:

Florida Department of Environmental Regulation	
s.17-6.010 F.A.C.	Wastewater Facilities
s.17-7.001 F.A.C.	Solid Waste Facilities
s.17-7.200 F.A.C.	State Resource Recovery and Management Program
s.17-7.500 F.A.C.	Domestic Sludge Classification, Utilization, and Disposal Criteria
s.17-7.600 F.A.C.	Used Oil
s.17-12.015 F.A.C.	Dredge and Fill Activities
s.17-14.01 F.A.C.	Detergents
s.17-16.200 F.A.C.	Water and Domestic Wastewater Plants
s.17-603 F.A.C.	Detergents
s.17-19.01 F.A.C.	Domestic Wastewater Treatment Plant Monitoring
s.17-25.001 F.A.C.	Regulation of Stormwater Discharges
s.17-27.010 F.A.C.	Mangrove Protection
s.17-28.11 F.A.C.	Underground Injection
s.17-28.700 F.A.C.	Ground Water Monitoring Requirements
s.17-30.001 F.A.C.	Hazardous Waste
s.17-31.01 F.A.C.	County and Regional Hazardous Waste Management Programs
s.17-34.00 F.A.C.	Polychlorinate Biphenyls
s.17-35.001 F.A.C.	Hazardous Waste Collection Center
s.17-301 F.A.C.	Surface Water of State
s.17-302 F.A.C.	Surface Water Quality Standards
s.17-312 F.A.C.	Dredge and Fill Activities
s.17-321 F.A.C.	Mangrove Protection
s.17-40.01 F.A.C.	Water Policy
s.17-43.010 F.A.C.	SWIM Rule
s.17-45.001 F.A.C.	25-Year Permits for Maintenance Dredging in Deepwater Ports
s.17-60.001 F.A.C.	Pollution Prevention and Control
s.17-61.001 F.A.C.	Stationary Tanks
s.17-63.01 F.A.C.	Local Tank Regulation Program
s.17-550 F.A.C.	Drinking Water Standards, Monitoring and Reporting

s.17-701.001 F.A.C.	Solid Waste
s.17-710.100 F.A.C.	Used Oil
s.17-761 F.A.C.	Underground Storage Tank Systems
s.17-762 F.A.C.	Aboveground Storage Tank Systems
s.17-769 F.A.C.	Florida Petroleum Liability Insurance and Restoration Program
s.17-770 F.A.C.	Clean-Up Criteria Rule

<u>Florida Department of Natural Resources</u>

s.18-18 F.A.C.	Biscayne Bay Aquatic Preserve
s.18-21 F.A.C.	Florida Aquatic Preserves
s.18-21 F.A.C.	Sovereignty Submerged Lands
s.18-21.041 F.A.C.	Special rule adopted in 1985 to augment the existing rules governing management of sovereignty submerged lands in the Keys (new rulemaking in progress regarding live-aboard vessels)

Activities of the Florida Marine Patrol to enforce state regulations under the authority of the following:

Chapter 161 F.S.	Beach and Shore Protection
Chapter 376 F.S.	Pollutant Discharge Prevention and Removal.

<u>Department of Health and Rehabilitative Services</u>

s.10D-6 F.A.C	On-Site Disposal Systems.

3.5.5 Impacts of the Future Land Use Plan on Water Quality

Natural and anthropogenic pollutant loadings will determine the future quality of the waters of the Florida Keys. Anthropogenic loadings will be most affected by the level of population growth, the spatial distribution of the increased population, required treatment efficiencies of wastes from the existing and additional populations, and selected disposal mechanisms for wastewater (CSA, 1991).

Based upon the limited water quality data for the Keys, it is evident that a comprehensive water quality monitoring program is needed to evaluate existing and future pollution threats. Despite this lack of data, evidence does exist to suggest that organic/nutrient loading may represent a serious long-term threat to water quality (CSA, 1991).

At this time it is not possible to predict present or future nutrient loadings due to the lack of data on measured loadings to the groundwater, transport of groundwater nutrients to marine waters, measured constituents in stormwater, and quantity of stormwater discharge to marine waters via groundwater and overflow (CSA, 1991).

Several factors, however, suggest that future loadings will decrease by the Year 2010. Population growth rate reductions resulting from plan implementation will result in lower than predicted nutrient loadings as modeled in previous studies (Camp Dresser & McKee, 1990). Loadings are expected to be further reduced through nutrient effluent and/or water quality standards. County water quality levels of service, particularly for OSDS nutrient removal, are expected to become more strict following completion of the Sanitary Wastewater Management Plan and the Stormwater Management Master Plan. Other programs targeting specific nutrient loading sources of Monroe County, combined with state and federal actions resulting from implementation of the Florida Keys National Marine Sanctuary Program are also expected to further reduce loadings from all sources.

3.6 Fresh Surface Water Resources

3.6.1 Occurrence of Fresh Surface Water Resources

Rainfall is the only natural source of freshwater in the Keys. Discharge is by evapotranspiration, surface runoff, pumpage, and lateral seepage from the shallow groundwater table. On most islands, groundwater throughflow moves quickly down-gradient into marine nearshore waters. Surface runoff discharges in the Keys do not form natural freshwater creeks and rivers. In many areas, mosquito control ditches and canals dug from the coast to inland parts of the islands to obtain fill for housing construction, have reduced the historical residence times of freshwater on the islands, thereby accelerating surface water runoff (Schomer and Drew, 1982; Hanson, 1980).

In areas on several larger keys, freshwater infiltrating from the surface enters the groundwater table and forms freshwater lenses (see Natural Groundwater Aquifer Recharge Chapter). The size of these lenses is controlled by rainfall, freshwater discharge (seepage, pumpage, runoff, evapotranspiration), response to tidal fluctuations, proximity to saltwater bodies, permeability of the subsurface materials, and elevation of the island above sea level (Klein, 1970; Hanson, 1980).

Freshwater lenses in the Keys occur on Key West, Big Pine Key, Cudjoe Key, No Name Key, Ramrod Key and Sugarloaf Key (see Natural Groundwater Aquifer Recharge Chapter). On many of these keys freshwater wetlands are associated with these freshwater lenses (see Section 3.9.7 below).

3.7 Floodplains

3.7.1 Floodplain Occurrences

Most of the land area in the Florida Keys is 2 to 3 feet above high tide. Maximum elevations reach 18 feet in two locations. As a result, the Keys are extremely susceptible to storm flooding.

Floodwater sources potentially affecting the Keys include the Atlantic Ocean, Florida Bay, Biscayne Bay and the Gulf of Mexico. In general, coastal areas which border these water bodies, are subject to storm surge flooding as a result of hurricane and tropical storm activity. Large tidal surges, combined with wave action and heavy rainfall that accompany these storms typically can result in severe flooding.

In 1989, the Federal Emergency Management Agency completed a detailed coastal flooding analysis of the complete coastline of Monroe County (FEMA, 1989). This study investigated the existence and severity of flood hazards. Both floodplain maps and flood elevations were developed. Analyses were carried out to establish the peak elevation-frequency relations for each flooding source. Hydraulic analyses, considering storm characteristics and the shoreline and bathymetric characteristics of the flooding sources studied, were completed to provide estimates of the elevations of floods of the selected recurrence intervals along all shorelines in the Keys (FEMA, 1989).

Flood zone designations which have been assigned to areas within Monroe County are as follows (FEMA, 1989):

Zone AE

Zone AE...corresponds to the 100-year floodplain that are determined in the Flood Insurance Study by detailed methods. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone VE

Zone VE...corresponds to the 100-year coastal floodplain that have additional hazards associated with storm waves. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone X

Zone X...corresponds to areas outside the 100-year floodplain, areas of 100-year flooding where average depths are less than one foot, areas of 100-year flooding where the contributing drainage area is less than one square mile, and areas protected from the 100-year flood by levees. No base flood elevations of depths are shown within this zone.

The Comprehensive Plan Map Atlas includes Natural Features Maps showing areas within the Upper, Middle and Lower Keys and selected offshore islands which are located outside of the 100-year floodplain (Zone X). These maps are available at a scale of 1"=2,000' and can be reviewed at the Monroe County Department of Planning.

3.7.2 Existing Commercial, Recreational or Conservation Uses in Floodplain

Flood elevations for the coastal storm having a recurrence interval of 100 years (Zone AE) range from 7 feet to 12 feet NGVD. Because most of the Keys lie below this elevation, water from this intensity storm would flood most areas.

Only a few keys have land which lies above the 100-year flood elevation (within Zone X). This includes land along US 1 on Key Largo, Plantation Key, Windley Key and Upper Matecumbe Key, comprised of a strip encompassing the highway right-of-way and adjacent lands approximately 1,000 feet in width. The only exception is on Key Largo from the Card Sound turnoff south to Florida 107, where the area outside of the floodplain narrows to include only the US 1 right-of-way. Other areas in the Keys outside of the floodplain include the sites of the US 1 bridge abutments on Big Pine Key at Spanish Harbor Channel and North Pine Channel.

Because of the extensive nature of the 100-year floodplain in the Florida Keys, most developed land uses within the Keys lie within its limits. Only the residential and commercial uses along US 1 on Plantation Key, Windley Key and Upper Matecumbe Key are outside of the floodplain. Most public and private recreational uses in the Keys are within the 100-year floodplain. Conservation lands are almost exclusively located on land within the 100-year floodplain.

3.7.3 Known Pollution Problems and/or Issues Related to Flooding Hazard

The potential for surface water contamination from flooding in the Keys arises primarily from the widespread use of poorly functioning on-site wastewater disposal systems or complete lack of a system. When flooded these systems typically can provide little or no treatment and wastewater is discharged relatively untreated into the soil or directly into adjacent surface waters. This condition would persist following subsidence of flood waters until soil moisture is reduced to normal levels.

The potential for surface water contamination from flooding also exists where hazardous materials and hazardous wastes are stored. However, aboveground and underground storage tanks, if constructed and maintained according to current state and federal regulations, should be adequately protected from rupture by flood waters and should not constitute a serious threat of contamination.

Pollutant loadings to surface water from urban runoff would be elevated during major storms.

3.7.4 Potential for Conservation, Use or Protection of Floodplain

Because most of the Keys are located within the 100-year floodplain, potential activities for conservation, use or protection of floodplain are related to those which:

(a) prevent disturbances to areas which provide critical flood water storage and filtration functions, including mangroves, salt ponds, saltmarsh and buttonwood wetlands, and freshwater wetlands;

(b) prevent excessive clearing and disturbance to natural upland vegetation within the floodplain; and

(c) minimize the alteration of natural drainage patterns within the floodplain.

Lands which retain natural floodplain functions or water storage and filtration should be retained where possible, in their natural condition. In the Keys these include all wetlands. Development activity should be directed away from areas of high quality upland vegetation which lies in the floodplain, including hardwood hammocks and pinelands. Land clearing, grading and filling should not disturb natural drainage patterns.

3.8 Living Marine Resources

The waters of the Florida Keys include three unique and critically important marine biological communities (CSA, 1991):

(a) mangrove forests along the shorelines of the Keys;

(b) seagrass beds (estimated to be some of the largest in the world) lying on both sides of the Keys and extending offshore to the reef tract; and

(c) The Florida Reef Tract, containing the only true coral reefs within the continental United States.

The Comprehensive Plan Map Atlas includes Natural Features Maps showing areas within the Upper, Middle and Lower Keys and selected offshore islands which are characterized by mangrove forests. These maps are available at a scale of 1"=2,000' and can be reviewed at the Monroe County Department of Planning.

Detailed mapping of the coral communities and seagrass beds of the Florida Keys is now in preparation as part of the Florida Keys National Marine Sanctuary Management Plan. This information will be made available to Monroe County by NOAA for entry into the County's Geographic Information System.

3.8.1 Mangroves

The natural margins of the Florida Keys are characterized by well-developed mangroves and adjacent shallow flats. Mangroves are a pan-tropical species, occurring on seventy-five percent of the world's tropical coastline (McGill, 1959). In Florida, the largest mangrove forests (90 percent) are located in the more southern areas of the state, primarily in Lee, Collier, Dade and Monroe Counties. Monroe County encompasses approximately 234,000 acres (95,000 ha.) of mangroves, the majority lying within the boundaries of Everglades National Park and the small islands in Florida Bay (Florida DNR, 1991c).

A. Flora of Mangrove Communities

The mangrove community is comprised of a diverse association of salt tolerant plants that provide food and habitat for a characteristic fauna. The major environmental conditions that characterize mangrove communities are:

(a) loose, wet, saline soil;

(b) periodic tidal submergence;

(c) occasional tropical storms and/or hurricanes; and

(d) low-energy wave and current regimes.

In South Florida three species of mangroves occur. Red Mangrove (Rhizophora mangle) has characteristic stilt, prop and aerial roots and bears the cigar-shaped, viviparous seedlings. Black Mangrove (Avicennia germinans) has pneumatophore breathing roots and gray-green leaves encrusted with excreted salts. White Mangrove (Laguncularia racemosa) has rounded leaves with a pair of salt glands on the petiole. Buttonwood (Conocarpus erectus) is often associated with the mangroves but is not a dominant. It occurs more frequently in the transitional zone that lies on slightly higher ground between the mangroves and upland systems. Other plants commonly associated with the mangroves include a number of fleshy halophytes, e.g. Saltwort (Batis maritima), Glasswort (Salicornia virginica), etc.

Four major factors limit the distribution of mangroves and determine the extent of mangrove ecosystem development (Odum, et al. 1982): climate; salt water; tidal fluctuation; and substrate. Mangroves do not develop where the annual average temperature is below 66 degrees F or where water temperatures exceed the 107 to 113 degree F range. Mangroves are facultative halophytes which do not develop in freshwater environments because they are not able to compete successfully with other plants in that environment.

Lugo and Snedaker (1974) have classified mangrove systems into six types based upon their physical structure. Five types occur in the Florida Keys, including overwash forest, fringe forest, riverine forest, basin forest, and scrub or dwarf forest.

Overwash Mangrove Forests

Overwash forests are found on small keys or peninsulas. In many cases overwash forest is the only community on a small island. These forests are regularly overwashed by tides and often contain no land that rises above mean high water. All three mangrove species may be present, but Red Mangroves are usually the dominant form, with canopy height ranging from 20 to 25 feet. Because of the regular tide sheet overflow, litter does not accumulate and organic export rates are high.

Fringe Mangrove Forests

Fringe forests form along low-energy shorelines. They are variable in width and canopy height, with trees typically widely spaced and medium to large (ranging from 20 to 30 feet in height). They exhibit traditional zonation patterns. Low tide and current velocities allow for colonization by mangroves and for the import and subsequent accumulation of sediments. The prop roots of Red Mangrove and the pneumatophores of Black Mangrove are particularly effective in sediment accumulation. Fringing forests that face open bodies of water to the north accumulate vast amounts of detritus, much of which is generated by the productive nearshore seagrass communities. The organic sediments that accumulate within the fringe forest are often strongly anaerobic, comprised of a mixture of organic sediments and coarse, calcareous sand. In these soils, Black Mangroves tend to dominate, probably because their pneumatophores allow access by underground portions of the tree to atmospheric gases. In fringe forests, populations of succulent, salt tolerant plants often form a dense ground cover, most commonly including Saltwort and Glasswort.

Riverine Mangrove Forests

Riverine forests occur along creeks and rivers on the mainland. In the Keys they occur only along tidal creeks. All three species of mangroves may occur, but the dominant form is usually Red Mangrove. On the mainland, this forest contains the largest trees of all the forest types, with canopy heights in excess of 60 feet; however, in the Keys the structure is similar to that of the fringe forest. Regular tidal influence promotes relatively high rates of nutrient export.

Basin Mangrove Forests

Basin forests typically occur in the Keys where large shallow depressions in the caprock foster the accumulation of soil and channelize tidal flow. Most are located on Key Largo. Basin forest structure is similar to overwash forests, but the Red Mangrove is not as dominant. The occurrence of Black and White Mangroves becomes more frequent with increasing soil elevation and diminishing tidal influence.

Scrub or Dwarf Mangrove Forests
Scrub or dwarf forests are best developed in the Lower Keys. These communities lack the canopy height and high productivity characteristic of the other forest types. Both the scrub and dwarf associations are characterized by small trees with an understory of scattered, salt tolerant shrubs, herbs and graminoids. The scrub community generally contains all three species of mangrove but is usually dominated by Black. Most trees are widely spaced and stunted. Dwarf mangrove associations contain trees less than five feet in height, with less distance between trees than in scrub forests. The association is dominated by dwarfed Red Mangroves. Both the scrub and dwarf forests occur in intertidal areas that do not experience daily tidal flushing. The minimal flushing may be attributable to natural waterward impediments to flow or to a great spatial separation from open water that alternates tidal flow. Dwarf Red Mangroves appear to occur on slightly lower elevations than scrub black mangroves.

In many areas of the Lower Keys (e.g. Sugarloaf, Saddlebunch and Torch Keys), scrub and dwarf forests occur where a number of conditions exist making it difficult for mangroves to colonize. The oolitic caprock is emergent in these areas, providing limited opportunity for soil accumulation. Where soils do occur, they are characteristically thin, saline marls within shallow caprock depressions. Due to the lack of regular tidal flushing, soils often become hypersaline during the dry season and dilute during the wet season. Propagules are less likely to reach these areas since they are dispersed by the tides.

B. Existing Commercial, Recreational or Conservation Uses of Mangroves

Uses in Mangroves on Private Lands
Non water-related uses (exclusive of utility pilings) are not permitted in mangroves in Monroe County. Sections 9.5-262 and 9.5-343 of the Monroe County Land Development Regulations (LDR's) (Monroe County BOCC, 1990) establish a 100 percent open space requirement for all native areas vegetated with mangroves, with an allocated density (du's/ acre) and maximum net density (du's/buildable acre) of zero.

Section 9.5-345 of the LDR's (Monroe County BOCC, 1990) provides further protection to mangroves by specifying the types of water-related and utility structures allowed. These Environmental Design Criteria are as follows:

(a) "only piers, docks, utility pilings and walkways shall be permitted on mangroves; and

(b) all structures on mangroves shall be designed, located and constructed such that:

i. all structures shall be constructed on pilings or other supports; and
ii. bulkheads and seawalls shall be permitted only to stabilize disturbed shorelines or to replace deteriorated existing bulkheads and seawalls."

Disturbances to shoreline fringing mangroves on unaltered shorelines are not permitted by Section 9.5-286 of the LDR's (Monroe County BOCC, 1990). A shoreline setback is required as follows:

"All buildings other than docks, utility pilings, walkways, nonenclosed gazebos and fences and similar structures shall be set back fifty (50) feet from natural water bodies with unaltered shorelines or unlawfully altered shorelines, measured from the landward limit of mangroves, if any, and where mangroves do not exist, from the mean high tide line."

Mangrove trimming is permitted by DER pursuant to its rules found in Chapter 17-321 F.A.C. These restrict mangrove trimming to the minimal alteration necessary to maintain navigation in existing navigable channels and canals, or where necessary to allow an upland owner limited ingress and egress to open waters.

Conservation Lands Encompassing Large Tracts of Mangroves
Conservation lands in the Florida Keys which encompass large tracts of mangroves include:

National Key Deer Refuge;
Great White Heron National Wildlife Refuge;
Key West National Wildlife Refuge;
Crocodile Lake National Wildlife Refuge;
John Pennekamp Coral Reef State Park (3,068 acres);
Lignumvitae Key Aquatic Preserve;
Biscayne Bay-Card Sound Aquatic Preserve;
Coupon Bight Aquatic Preserve; and
Coupon Bight/Key Deer CARL Project.

C. Known Pollution Problems and/or Issues Related to Mangroves

Until 1975, mangroves in the Florida Keys were filled routinely for purposes of providing dry land for development. In 1986 Monroe County adopted its current Land Development Regulations (see above) which effectively stopped such activities in the Keys.

Pollution problems and other concerns related to mangroves which remain today include:

(a) problems related to mangrove trimming by private landowners;

(b) problems related to removal of fringing shoreline mangroves for construction of shoreline structures, particularly docks; and

(c) problems related to water quality deterioration in the nearshore environment as a result of existing population levels and practices.

Homeowners and business owners in mangrove areas throughout the Keys believe that mangrove trimming is not detrimental and continue to request permits from DER to trim the trees to maintain marine access as well as water views (Florida DNR, 1991e). DER routinely issues these permits subject to rules found in Chapter 17-321 F.A.C. While there is some disagreement over the effects of mangrove trimming, most biologists believe that severe trimming of mangroves (e.g., 33 percent of canopy) will kill some trees and affect reproduction (Florida DNR, 1991e). Red mangroves are especially sensitive to trimming. There is a need for further research to evaluate the impacts of this trimming and refinement to mangrove trimming regulations based upon the findings of this research.

Fringing shoreline mangroves occur along much of the Keys' unaltered open water shorelines as well as along altered shorelines and shorelines of artificial waterways. Where mangroves are growing in partially built-out residential subdivisions, they provide biological functions locally beneficial to nearshore water quality and wildlife. Typically, when development occurs on lots with shoreline mangroves, the developer/landowner seeks to stabilize the shoreline, to backfill, and to construct shoreline structures and/or structures over the water, such as docks. Where existing federal, state and local regulations have allowed some of these types of activities to occur there has been loss of valuable biological functions in already stressed environments.

To date there have been no major mangrove losses in the Keys as a result of water quality (CSA, 1991). Mangroves are relatively insensitive to nutrient loading and are not adversely affected by highly eutrophic waters (CSA, 1991; Odum and McIvor, 1990). However, some studies have revealed sensitivities to certain contaminants. Mangroves, particularly red mangroves, are highly susceptible to herbicides (CSA, 1991; Teas and Kelly, 1975). Petroleum and petroleum byproducts have deleterious effects on mangroves due to the toxic effects of oil and to the prevention of aeration caused by clogging of root lenticels and pneumatophores (CSA,1991; Lewis 1980; de la Cruz, 1982). Mangroves can be killed by heavy suspended loads of fine, flocculent material which clog root lenticels and pneumatophores (CSA, 1991).

D. Potential for Conservation, Use or Protection of Mangroves

The Florida Keys National Marine Sanctuary (FKNMS) Management Plan (see Section 3.5.4 A above) will provide the basis for future federal, state and local conservation activities affecting the resources of the Sanctuary, including its mangrove forests. The Plan will identify the regulatory strategies and alternative institutional responsibilities for resource protection. It will include a plan for public education regarding mangrove conservation, as well as recommendations for a mangrove research program.

As part of the FKNMS Management Plan, the FKNMS Water Quality Protection Program (see Sections 3.5.4.A and B above) will:

(a) adopt or revise water quality standards to assure protection of marine resources, including mangroves;

(b) adopt pollution control measures and methods to eliminate or reduce pollution from point and non-point sources, including those which are found through future research to affect marine resources, including mangroves; and

(c) establish a comprehensive water quality monitoring program.

The Monroe County Department of Marine Resources will be responsible for implementing regulations and management guidelines at the FKNMS Management Plan and FKNMS Water Quality Protection Program at the local level. This will be undertaken through a memorandum of agreement with NOAA, EPA, SFWD and DER, to be executed upon adoption of the FKNMS Management Plan and the FKNMS Water Quality Protection Plan.

The County anticipates supporting the mangrove research program and the public education program regarding mangrove conservation. The most significant opportunity for the County to participate in the effort to conserve the mangrove communities of the Keys will be to implement the water quality protection policies, programs, and regulations of the Comprehensive Plan and the FKNMS Water Quality Protection Program. These activities are discussed above in Section 3.5.4.F.

The Monroe County Department of Marine Resources has identified several conservation actions which could be taken at this time to further protect mangroves:

Mangrove Trimming:
Monroe County currently relies on DER to regulate mangrove trimming pursuant to rules found in Chapter 17-321 F.A.C. The County would like to develop a local mangrove trimming ordinance which will provide further protection to mangroves. Particular attention is needed to refining regulations pertaining to mangrove trimming whose sole purpose is for visual access to the water.

Vegetated Setbacks Adjacent to Mangroves:
Revisions to the Land Development Regulations (LDR's) should establish a vegetated setback adjacent to all types of wetlands, including mangroves. This setback would function to protect mangroves from physical destruction and from contaminated stormwater runoff.

Shoreline Setbacks Along Shorelines with Fringing Mangroves: Current county policy and regulations regarding permitted uses and design criteria in shoreline setbacks are in need of review and revision. Such review and revision should be undertaken in cooperation with DCA. Policies and regulations should be designed to protect nearshore waters from stormwater flows from adjacent uplands, to protect fringing mangroves, and to maintain water views.

Dock Construction and Shoreline Stabilization on Shorelines with Fringing Mangroves:
Recent experience with permit applications has indicated a need to clarify existing policies and regulations pertaining to dock construction and shoreline stabilization on shorelines with fringing mangroves. Such review and revision should be coordinated with DCA, DNR and DER to ensure consistency with state and federal policies. Regulations should strictly limit shoreline improvements which either take or disturb fringing mangroves (i.e., through runoff, shading, or destruction) resulting in loss of biological function.

3.8.2 Seagrass Beds

The seagrass community is a highly productive, faunally rich system that covers a larger area than any other ecosystem in Monroe County. Of the 10,000 square kilometers (sq km) of seagrass in the Gulf of Mexico, over 8,500 sq km are in Florida waters, primarily in Monroe County (Zieman, 1982). Seagrasses cover over 80 percent of the sea floor in the area bounded by Cape Sable, north Biscayne Bay and the Dry Tortugas, an area of over 5,500 sq km (Zieman, 1982).

Seagrass meadows also are important in stabilizing sediments that would otherwise exist as shifting sand and mud. As such, they represent a critical element in preventing or at least retarding the loss of continental materials that would otherwise be lost by erosion to the ocean.

A. Flora of Seagrass Beds

The seagrass beds in Monroe County are dominated by three species: Turtle Grass (Thalassia testudinum), Manatee Grass (Syringodium filiforme), and Shoal Grass (Halodule wrightii). These species persist from year to year in the same general location and form large, complex, and extremely significant biological habitats (CSA, 1991).

Turtle grass is the most robust and widespread of the seagrasses, forming extensive meadows throughout its range. It is a climax species and as such, is considered the primary producer of the seagrass community. Manatee grass is more surficially rooted than turtle grass and rarely forms extensive meadows, occurring most commonly mixed with other species or in small dense monospecific patches. Shoal grass is found primarily in disturbed areas that are devoid of turtle grass or manatee grass and is an important early colonizer of such sites. Overall, it is the most eurycious of the principal seagrass species in that it thrives in water too shallow or too deep for the other species and is the most tolerant of all species to variations in temperature and salinity (Zieman, 1982). Less common seagrass species include three species of Halophila (Halophila decipiens, Halophila engelmanni, Halophila johnsonii). These are diminutive, vascular plant species, sparsely distributed in seagrass communities, which do not form permanent seagrass beds.

Grassbed distribution is determined primarily by factors influencing light intensity, current velocity and sediment depth. Turtle grass requires depths of from 3 to 20 inches (Scoffin, 1970; Zieman, 1972) of sediment for optimum growth. Areas with thin sediments may be more readily colonized by less selective shoalweed or species from the hardbottom community (Florida DNR, 1991c).

Only a few types of benthic algae are capable of colonizing the bottom sediments, notably members of the genera Halimeda, Penicillus, Caulerpa, Rhipocephalus, and Udotea. These species are early colonizers of marine sediments which act to stabilize sediments so that seagrasses may become established. Laurentia, a species of drift algae, also commonly occurs in grassbeds. Seagrass leaves also provide substrate for some 66 species of epiphytic algae (Ballantine and Humm, 1975).

B. Fauna of Seagrass Beds

The seagrass beds are transitional habitats between the coral reef and mangrove habitats. As such, they are important to many species of both ecosystems. They provide abundant food and shelter for a myriad species of fish, sea turtles, and invertebrates. They represent the richest nursery and feeding grounds in South Florida's coastal waterways. In addition to representing a primary resource for grazers, seagrasses provide vast amounts of energy via detritus that may cycle internally or be exported to mangrove or coral reef communities. (See Section 3.14 for a discussion of the fish common to seagrass beds.)

Faunal constituents of the marine grassbed community include a diversity of microscopic zooplankton, epiphytic biota, pelagic invertebrates, fishes and mammals. A large number of birds feed extensively in shallow seagrass meadows (see Table 3.8).

Table 3.8

Birds Using Seagrass Flats in Florida Keys

Common Name	Species Name	Preferred Feeding Tide
Waders		
Great Blue Heron	*Ardea herodias*	low
Great White Heron	*A. herodias*	low
Great Egret	*Casmerodius albus*	low
Snowy Egret	*Egretta thula*	low
Little Blue Heron	*E. tricolor*	low
Tricolored heron	*E. tricolor*	low
Reddish Egret	*Egretta rufescens*	low
White Ibis	*Eudocimus albus*	low
Roseate Spoonbill	*Ajaja ajaja*	low
Black-bellied Plover	*Pluvialis squatarola*	low
Wilson's Plover	*Charadrius wilsonia*	low
Semipalmated Plover	*C. semipalmatus*	low
Willet	*Catoptrophorus semipalmatus*	low
Ruddy Turnstone	*Arenaria interpres*	low
Red Knot	*Calidris canutus*	low
Western Sandpiper	*C. mauri*	low
Least Sandpiper	*C. minutilla*	low
Dunlin	*C. alpina*	low
Short-billed Dowticher	*Limnodromus griseus*	low
Swimmers		
Horned Grebe (winter only)	*Podiceps auritus*	high
American White Pelican (winter only)	*Pelecanus erythrorhynchos*	high
Double-crested Cormorant	*Phalacrocorax auritus*	high
Red-breasted Merganser	*Mergus serrator*	high
Flying Plungers		
Borwn Pelican	*Pelecanus occidentalis*	high
Osprey	*Pandion haliaetus*	high
Bald Eagle	*Haliaeetus leucocephalus*	high
Laughing Gull	*Larus atricilla*	high
Ring-billed Gull (winter only)	*L. delawarensis*	high
Herring Gull (winter only)	*L. argentatus*	high
Royal Tern	*Sterna maxima*	high
Forster's Tern (winter only)	*S. forsteri*	high
Least Tern (summer only)	*S. antillarum*	high

Source: Monroe County Department of Planning, 1986.

The only reptile for which seagrass constitutes a principal feeding habitat is the Green Sea Turtle (Chelonia mydas).

Two aquatic mammals know commonly to use seagrass communities are the Caribbean Manatee (Trichechus manatus) and the Bottlenose Dolphin (Tursiops truncatus). While Bottlenose Dolphins are common in South Florida waters generally, they are not especially common in shallow seagrass meadows in Florida Bay because the extreme shallowness precludes extensive utilization by such a large mammal.

C. Existing Commercial, Recreational or Conservation Uses of Seagrass Beds

Recreational boating and fishing are the primary activities which occur in seagrass beds in the Florida Keys. Popular sportfishing in seagrass beds is for tarpon (Megalops atlanticus), bonefish (Albula vulpes), and permit (Trachinotus falcatus).

The Florida Keys National Marine Sanctuary (FKNMS) encompasses all of the submerged lands and waters of the Florida Keys extending from the mean high water mark to the offshore sanctuary boundary. This lies at the approximate 300-foot depth contour line (Public Law 101-965). Excluded areas include Everglades National Park, Biscayne National Park and Fort Jefferson National Monument. All seagrass beds within these designated sanctuary boundaries are protected and subject to future management through the FKNMS Management Plan and the FKNMS Water Quality Protection Program (see Section 3.5.4 A). Marine resources presently under state management on state-owned lands will also be subject to these future management programs through memoranda of agreement between NOAA, EPA, DER, SFWMD and Monroe County anticipated in July/August 1993. Until that time management of sovereignty submerged lands has been retained by the State of Florida.

Conservation lands characterized by seagrass communities include:

John Pennekamp Coral Reef State Park;
Lignumvitae Key State Aquatic Preserve;
Biscayne Bay-Card Sound Aquatic Preserve;
Coupon Bight State Aquatic Preserve;
Great White Heron National Wildlife Refuge; and
Key West National Wildlife Refuge.

All of the above-listed conservation lands are within the boundaries of the FKNMS.

Areas within the Looe Key National Marine Sanctuary and Key Largo National Marine Sanctuary encompass large areas of seagrass beds. Management of these areas will be undertaken as part of the FKNMS once the FKNMS Management Plan is completed in the summer of 1993.

D. Known Pollution Problems and/or Issues Related to Seagrass Beds

Seagrass habitat losses in the Florida Keys National Marine Sanctuary have been directly related to natural habitat destruction by hurricanes and tropical storms, and to mechanical habitat destruction associated with development (CSA, 1991). To date there have been no major losses of submerged or emergent vegetation within the Sanctuary which can be unquestionably attributed to man-induced water quality degradation (CSA, 1991). Almost all of the information concerning declines in the seagrass beds of the region is anecdotal and speculative (CSA, 1991). Research indicates that degrading water quality will at some time lead to seagrass bed deterioration. However, quantitative data are not available either to determine the true extent of water quality degradation throughout the Sanctuary, or to definitively state whether or not seagrass bed deterioration is presently occurring in the Sanctuary (CSA, 1991). Despite this, there are disturbing signs observable today that suggest that the submerged vegetative community in nearshore areas in the Sanctuary may be coming under increasing stress due to water quality deterioration (CSA, 1991).

Hurricanes and tropical storms are the most significant natural disruptions of seagrass habitats. Seagrass communities are well adapted to these disturbances and typically recolonize shortly afterward. Research suggests that hurricanes may function to remove accumulated organic matter and sediments, particularly in Florida Bay (Zieman, et al., 1989).

Dredging in seagrass beds has historically caused the greatest amount of man-induced direct damage to nearshore submerged vegetation. Since the turn of the century, an estimated 2,000 hectares of seagrass beds have been lost by mechanical destruction, primarily dredging on submerged lands within the Sanctuary, representing a loss of approximately 0.35 percent of the total seagrass acreage (CSA, 1991). Dredged areas are rendered unsuitable for seagrass recolonization for long periods or permanently in locations where dredged depths exceed those tolerated by seagrasses (Zieman, 1975).

Cuts from boat propellers are today the most common type of man-induced direct damage to seagrass beds in South Florida (Zieman, 1975). Damage occurs when recreational boaters take watercraft and jet skis through shallows, and propellers cut through beds of seagrass and shallow sediments. Recovery from a single prop cut begins in about two years and takes at least five years for completion (Zieman, 1975). Multiple cuts in grass beds frequented by boaters may persist for a decade or more.

Boat mooring and dock construction in the vicinity of seagrass beds has potential adverse impacts on seagrasses both directly through bottom disturbances and shading, and indirectly through pollutant discharges from vessels.

The indirect causative mechanisms for the loss of seagrass beds in the Sanctuary are not well known. Typically losses are attributed to the general development of the watershed and the coastline that influences the seagrass beds (CSA, 1991). It is difficult to precisely identify the exact pollutants and mechanisms which may be impacting submerged vegetation because human activities tend to alter many water quality characteristics simultaneously (CSA, 1991). Water quality factors that have been implicated in declines in submerged vegetation include: alterations in the physical parameters of temperature, salinity and sediment stability; toxic substances (such as herbicides, detergents and petroleum products), and; reduction of the quantity and quality of light that reaches seagrasses (CSA, 1991). It has been speculated that the diversion of freshwater and the changing hydroperiod of the Everglades drainage has changed the historic salinity regime in Florida Bay and may be responsible for the observed shift in Florida Bay seagrass communities from Halodule wrightii dominance to Thalassia testudinum dominance (Zieman, 1982; CSA 1992). Research also supports the conclusion that any factor that decreases the amount of light penetrating the water column may have a significant impact on seagrass beds (CSA, 1991).

Much speculation has occurred over the possible causes of recent seagrass die-off in Florida Bay. Since 1987, approximately 4,000 hectares of seagrasses have been completely denuded and another 23,000 hectares have been impacted to a lesser extent in Florida Bay (CSA, 1991). Most of this die-off has occurred within dense seagrass beds dominated by turtle grass (Thalassia testudinum) located in Everglades National Park. On the basis of three years of intensive investigation, researchers from DNR, Everglades National Park, Florida International University, University of Georgia, and University of Virginia have concluded that anthropogenic pollution is probably not responsible for this die-off (Robblee, et al., 1991). Two potential causes of the mortality are now under investigation including a pathogenic marine slime mold, and imbalances in the respiration/photosynthesis balance within the plants themselves (CSA, 1991). Other contributing factors under study include the abnormally long time since a major hurricane in the Florida Bay area, coupled with recent hot summers. This may have allowed abnormally high accumulations of sediments and organic matter, thereby supporting overly dense colonization.

E. Potential for Conservation, Use or Protection of Seagrass Beds

The Florida Keys National Marine Sanctuary (FKNMS) Management Plan (see Section 3.5.4 A above) will provide the basis for future federal, state and local conservation activities affecting the resources of the Sanctuary, including its seagrass beds. The Plan will identify the regulatory strategies and alternative institutional responsibilities for resource protection. It will include a plan for public education regarding seagrass bed conservation, as well as recommendations for a seagrass research program.

As part of the FKNMS Management Plan, the FKNMS Water Quality Protection Program (see Section 3.5.4 A and B above) will:

(a) adopt or revise water quality standards to assure protection of marine resources, including seagrass beds;

(b) adopt pollution control measures and methods to eliminate or reduce pollution from point and non-point sources, including those which are found through future research to affect marine resources, including seagrass beds; and

(c) establish a comprehensive water quality monitoring program.

The Monroe County Department of Marine Resources will be responsible for implementing regulations and management guidelines at the FKNMS Management Plan and FKNMS Water Quality Protection Program at the local level. This will be undertaken through a memorandum of agreement with NOAA, EPA, SFWD and DER, to be executed upon adoption of the FKNMS Management Plan and the FKNMS Water Quality Protection Plan.

The County anticipates supporting the seagrass research program and the public education program regarding seagrass conservation. The County's boating management activities (see below) will be coordinated with those of the FKNMS Management Plan. The most significant opportunity for the

County to participate in the effort to conserve the seagrass communities of the Keys will be to implement the water quality protection policies, programs, and regulations of the Comprehensive Plan and the FKNMS Water Quality Protection Program. These activities are discussed above in Section 3.5.4.F.

The Monroe County Department of Marine Resources has identified several conservation actions which could be taken at this time to further protect seagrass beds in nearshore waters:

Dredging and Filling:
Monroe County's dredging and filling policies should be codified in the Land Development Regulations. The County currently prohibits new dredging in the Florida Keys and prohibits maintenance dredging within areas vegetated with seagrass beds. Exceptions for maintenance dredging in seagrass bed areas are permitted only for public navigation channels where mitigation of adverse impacts on seagrass beds can be successfully accomplished. These prohibitions have eliminated the most historically significant direct impact of man's activities on seagrass beds in the Keys.

Mooring Sites:
Mooring sites, including those at docks are not permitted over seagrass beds, regardless of water depth. This eliminates potential concentrated impacts of bottom disturbances and pollutant discharges from moored vessels in the immediate vicinity of seagrass beds. Coordination is needed with DNR to develop a consistent policy related to the prohibition of mooring buoy fields over seagrass beds.

Dock Location and Design:
Monroe County currently allows docks to be constructed over seagrasses in order to reach waters with depths at least four (4) feet below mean low water. Revisions to the Land Development Regulations could be strengthened to better protect seagrasses if dock extensions are allowed over seagrasses only if there is no alternative dock walkway design which would reach waters with consistent navigational access without passing over seagrasses.

Boating Management:
The Monroe County Department of Marine Resources is currently developing a boating management program which will address several issues related to boating in the vicinity of seagrass beds. Specifically, these include channel marking in access areas around large keys, mooring buoy siting, recommended strategies to reduce seagrass prop scarring, recommended strategies to minimize vessel groundings, and improved boater education regarding conservation of seagrass beds. A boating speed control ordinance is under consideration for adoption.

Development of the County's boating management program is being undertaken in coordination with the FKNMS Management Plan.

3.8.3 Coral Communities

Coral communities are among the Earth's most complex and productive natural systems. The Florida Reef Tract of the Florida Keys is the only living coral reef system in the continental United States. It lies at the northern edge of the geographic range of coral systems. It extends southeast from Cape Florida, forming an arc paralleling the Keys for 220 miles (354 km) from Soldier Key to the Dry Tortugas (Miller, 1988). Coral communities are found from almost intertidally to 13 km offshore, in depths ranging from less than 1 m to 41 m (CSA, 1991). Seaward of the reef tract, the Florida Current provides the constant source of warm, tropical waters responsible for allowing coral development. The Florida Reef Tract reaches optimum development in the deeper waters, seaward of Hawk's Channel and landward of the Straits of Florida (Florida DNR, 1991c).

The structural framework of coral communities is composed of colonies of tiny organisms collectively called coral. The hard corals most prevalent in reef formation include Boulder Coral (Montastrea annularis), Large-cupped Boulder Coral (Montastrea cavernosa), Elkhorn Coral (Acropora palmata, Staghorn Coral (Acropoa cervicornis), Brain Coral (Diploria spp.) and Round Starlet Coral (Siderastrea siderea)(Japp 1984). The tiny organisms making up these colonies extract calcium carbonate from seawater to secrete calcareous chambers within which they live (the hard coral skeleton).

The pattern of reef development in the Keys approaches the "barrier reef" model. The most seaward component of this barrier complex is an outer reef system that develops at the crest of the escarpment at the outer edge of the shallow continental shelf that occurs along the Atlantic edge of the Keys. Because of the linear regularity of this geomorphological feature, outer reefs tend to linear systems that parallel the Keys. Landward of the outer reef lies a shallow lagoon and coral system characterized by less structural regularity of its coral components. These "patch reefs" are of scattered and irregular distribution, shape and size.

In the Keys the linear pattern of reef development is more broken than is typical of reef development in more southerly waters. It is actually a narrow band of disjunct reefs with many horizontal gaps or breaks in the reefs (Florida DNR, 1991c). This generally reflects the discontinuities in the chain of islands comprising the Keys, corresponding with the creeks, cuts or passes between the islands. The islands comprising the Upper Keys constitute a fairly continuous barrier to the exchange of water between Florida Bay and the Atlantic Ocean. Consequently, the Florida Current's thermally moderating influence is more constant than in the Lower Keys, where the archipelago is fragmented and there is greater tidal exchange between Florida Bay and the Atlantic Ocean. This exchange allows more pronounced differences in seasonal temperatures and generates more turbid water. Consequently, the Lower Keys reefs tend to be characterized more by isolated patches or marginal reefs rather than bank/barrier reefs, with the best developed communities occurring in the southern "shadows" of the major Lower Keys islands where environmental conditions are more constant (e.g., the Sambo reefs south of Big Coppitt and Geiger Keys, and Looe Key Reef south of Big Pine Key).

A. Biota of Coral Communities

Coral communities can be divided into four types based upon physical habitats and community structure patterns: bank reef, transitional reef, patch reef and hardbottom (also referred to as livebottom)(Japp 1984).

Differences in the physical environments of the reef types are reflected in the differing morphologies of their dominant coral species. The patch reefs of the lagoon area and the Lower Keys live in shallow water that is more strongly influenced by wave action that can increase turbidity, and by weather changes that can result in a range of thermal variation not present in the deeper waters of the outer reef. As a result, massive boulder-shaped corals whose morphology is better able to withstand high wave energy and turbidity dominate the reef system. By comparison, the corals along the outer reef do not experience such stressful conditions. There the thermal condition is stabilized by the influence of warm Florida Current waters, and sediments that could contribute to turbidity are instead transported into the ocean's depths by sand channels. As a result in part, many corals with branched and plated morphologies characterize the outer reef.

Bank Reefs

Bank reefs are located at or near the shallow shelf break. The elongated reefs form a discontinuous belt that is best developed seaward of Key Largo and the Lower Keys. This community receives the most beneficial nutrients, displays the most diverse associations, and exhibits the most highly developed super-structure (Florida DNR, 1991c). Many of the massive, reef building corals in the reef banks do not occur in the other coral community types. Kissling (1977) identified over 350 macrobenthic species, including 42 species of stony corals, 41 species of soft corals, and 21 species of brittle stars on nine outer reef off the Lower Keys.

Representative biota of the outer reefs include Porites astreoides, Lettuce Coral (Agaricia agaricites), Clubbed Finger Coral (Porites), Siderastres sidera, Elkhorn Coral (Acropora palmata), Staghorn Coral (A. cervicornis), Pillar Coral (Dendrogyra cylindrus), Gorgonia ventalina, Plexaura complanata, Diploria clivosa, the alcyonarians Plexaura flexuosa, Pterogorgia citrina, and Eunicea mammosa, the hydrozoan Millepora complanata, the green algae Halimeda, the Brittle Star Ophiothrix orstedii and Ophocnida sp, and coralline algae.

Transitional Reefs

Between bank reefs and patch reefs there is frequently a coral community with fauna found in both communities, referred to as the transitional reef. Under more favorable conditions (higher sea level), the transitional reef may in time develop into the more diverse reef bank (Florida DNR, 1991c). It also occurs on artificial substrates, such as sunken ships or other debris used to construct artificial reefs (Japp, 1984).

Patch Reefs

There are over 6,000 patch reefs between Miami and the Marquesas Keys (Schomer & Drew, 1982). Most occur in areas of sand, mud or rock substrate located in a band two to four miles from the islands between Hawk Channel and the outer reefs (Marszalek, et al., 1977). Colonization occurs where light, water temperature and nutrient conditions are favorable and where patch reef organisms are protected from the excessive sediments, temperature and salinity fluctuations of water circulating from Florida Bay. Patch reef development in nearshore waters (landward of Hawk's Channel) is known to occur in only a few locations in the Keys (Florida DNR, 1991c).

There are two basic types of patch reefs (Marszalek, et al, 1977; Japp, 1982). Dome patch reefs usually occur in clusters in water depths of less than 30 feet and vary in size from a few meters to more than 700 meters (Schomer & Drew, 1982). They are typically circular or elliptical and are surrounded by a halo of barren substrate. The community's biota varies greatly depending on reef age and environmental condition (Jaap, 1982), but typically consists of scleractinian and alcyonarian corals, other coelenterates, mostly erect sponges, echinoderms, crustaceans, molluscs, red and green algae, and a variety of fishes. Species diversity and density generally increase in proportion to the size of the patch reef (Florida DNR, 1991c).

Jones (1977) described a successional sequence for dome patch reefs in which the pioneer corals are likely to be Porites, Manicinia areolata, and Favia fragum. These forms are replaced by primary reefbuilding corals like the Starlet Coral (Siderastrea siderea), the Brain Coral (Diploria labrinthiformis and D. strigosa), the Star Coral (Montastrea annularis and M. cavernosa), the Finger Coral (Porites and P. furcata), and Colpophyllia natans.

The coral assemblage of linear patch reefs is similar to that of dome patch reefs, but Elkhorn Coral (Acropora palmata) joins Montastrea annularis as a principal reefbuilder. Linear patch reef usually occur seaward of dome patch corals and lie roughly in a chain parallel to the outer reefs. Both types of reefs commonly have the algae Gonialithon sp. and Halimeda opuntia, numerous erect sponges, bivalves of the genera Acra, Lithophaga, and Barbatia; the gastropods Strombus gigas and Corallophils abbreviata, Spiny Lobster (Panulirus argus), Stone Crab (Menippe mercenaria) the echinoids Diadema antillarium and Echinometra lucunter, numerous ostracods, bryozoans, foramnifera, and fishes (Enos, 1977; Multer, 1977; Japp, 1982).

Hardbottom

Hardbottom communities occur on large portions of the Atlantic sea floor and smaller portions of the lagoon bottom, extending from less than 1 m depth to depths greater than 30 m. Marine grassbeds, sand, and mud bars are usually intermixed with the hardbottom, occupying shallow depressions in the limestone (Florida DNR, 1991c). Distribution of macrofauna is generally scattered in random patterns and is never as compact or diverse as are grassbeds or coral reefs (Florida DNR, 1991c).

Hardbottom habitat supports a diverse invertebrate and vertebrate fauna, dominated by algae and invertebrate species such as soft corals, sponges, and small stony corals. The soft corals are visually dominant. The most common species are the Sea Whip (Pterogorgia spp.), Sea Fan (Gorgonia ventalina), Sea Rod (Pelxaura spp.), and Sea Plume (Pseudopterogorgia spp.)(Florida DNR, 1991c).

Stony corals found in the hardbottom community include Clubbed Finger Coral (Porites), Porous Coral (P. asteroides), Starlet Coral (Siderastrea radians), Rose Coral (Manicina areolata), Lobed Star Coral (Solenastrea hyades), and Smooth Star Coral (S. bournoni) (Florida DNR, 1991c).

Sponges are dominant in some areas of the lagoon, with the most prevalent species including the Chicken Liver Sponge (Chondrilla nucula), Vase Sponge (Ircinia campana), Cake Sponge (I. etherea), Stinking Sponge (I. felix), Little Blue Heavenly Sponge (Dysidea etherea), Large Loggerhead Sponge (Spheciospongia vesparia), and Tube Sponge (Aplysina cauliformis and Callispongia spp.) (Florida DNR, 1991c).

Algal species are well represented by the calcareous greens, Acetabularia, Batophora, Halimeda, and Udotea spp. (Florida DNR, 1991c).

Macrofauna of Coral Communities

Coral reef systems provide protection and shelter for colorful and diverse macrofauna, including small shrimp, crabs, fish and several species of lobsters. Many species, especially the larger predators, are important species for local fisheries. Hardbottom communities are valuable nursery areas for many invertebrates and fishes of both the patch reef and seagrass communities, providing microhabitats for many juvenile fishes. (See Section 3.14 for a discussion of the fish common in coral communities.)

B. Existing Commercial, Recreational or Conservation Uses of Coral Communities

Recreational boating, snorkeling, SCUBA diving, and fishing are the primary activities which occur in the coral communities of the Florida Keys. Over one million people visit the Florida Reef Tract annually (Miller, 1988).

As previously noted, the Florida Keys National Marine Sanctuary (FKNMS) encompasses all of the submerged lands and waters of the Florida Keys extending from the mean high water mark to the offshore sanctuary boundary. This lies at the approximate 300-foot depth contour line (Public Law 101-965). Excluded areas include Everglades National Park, Biscayne National Park and Fort Jefferson National Monument. All coral communities within these designated sanctuary boundaries are protected and subject to future management through the FKNMS Management Plan and the FKNMS Water Quality Protection Program (see Section 3.5.4 A above). Marine resources presently under state management on state-owned lands will also be subject to these future management programs through memoranda of agreement between NOAA, EPA, DER, SFWMD and Monroe County. Execution of these agreements is anticipated in July/August 1993. Until that time, management of state sovereignty submerged lands has been retained by the State of Florida.

Conservation lands characterized by coral communities include:

John Pennekamp Coral Reef State Park;
Lignumvitae Key State Aquatic Preserve;
Biscayne Bay-Card Sound Aquatic Preserve;
Coupon Bight State Aquatic Preserve;
Great White Heron National Wildlife Refuge; and
Key West National Wildlife Refuge.

All of the above-listed conservation lands are within the boundaries of the FKNMS.

Areas within the Looe Key National Marine Sanctuary and Key Largo National Marine Sanctuary encompass large areas of coral communities. Management of these areas will be undertaken as part of the FKNMS once the FKNMS Management Plan is completed in the summer of 1993.

C. Known Pollution Problems and/or Issues Related to Coral Communities

The Florida Keys National Marine Sanctuary (FKNMS) was established in recognition of the conservation, recreational, commercial, ecological, research, educational and aesthetic values which render the Florida Reef Tract and its surrounding marine environments a resource area of national significance. The Act (Public Law 101-965) establishing the FKNMS recognizes that "these marine environments are subject to damage and loss of their ecological integrity from a variety of sources of disturbance".

Numerous studies have documented or suggested the threats which currently exist to coral communities in the Florida Keys from natural and man-made causes (The Nature Conservancy, 1990; Glynn, et al, 1989; Lapointe, 1989a; Skinner and Corcoran, 1989; U.S.D.C., NOAA, 1988; Dustan and Halas, 1987). While there is a consensus that the reefs are declining, there is considerable disagreement among researchers, regulators, and resource managers as to the causes of this decline.

The FKNMS Management Plan, now in preparation pursuant to Public Law Public Law 101-965, will identify and propose for adoption a management plan which designed to protect the resources of the FKNMS and which manages human uses within it. As part of this process, NOAA as the Lead Agency, in cooperation with EPA, DER, SFWMD and Monroe County, is documenting the extent of decline of the coral communities within the Sanctuary, identifying the probable causes of this decline, and assessing alternative management strategies for resource protection. This plan will eliminate the present lack of consistent management policies for Florida Keys' marine environments outside of Looe Key and Key Largo National Marine Sanctuaries, claimed by many to be partly responsible for decline of coral communities (U.S.D.C., NOAA, 1988).

In general, the coral communities of the Keys are affected by a number of factors, both natural and man-induced. Findings of the Research Planning Workshop for the FKNMS (NOAA and RSMAS, 1991) identified the following major stresses on coral communities as:

<u>Water Quality</u>	
groundwater	temperature extremes
reduced light	allocthonous bacteria and viruses
suspended sediments	pesticides and hydrocarbons
chronic nutrients	
<u>Global Change</u>	
sea level rise	temperature increases
<u>Physical</u>	
anchoring	marine debris
diver impact	collection damage
fishing gear	large and small vessel groundings.

Perhaps the most frequently cited stress on coral communities is anthropogenic water pollution resulting in elevated nutrient loading to the offshore waters of the Florida Reef Tract. In an effort to understand the natural and man-induced factors affecting the vitality of coral communities in the FKNMS, Phase I of the FKNMS Water Quality Protection Program includes a Coral Community Assessment (Task 3) (CSA, 1991). The assessment presents a review of available scientific data and literature on the Keys' coral communities, as well as conversations with acknowledged coral community experts. Findings from this study indicate that available data support the following conclusions (CSA, 1991):